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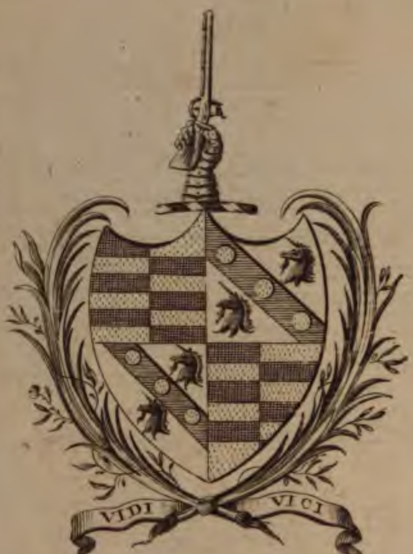

THE REV^{D}.

GEORGE SCURFIELD; A.M.

PYRITOLOGIA:

OR, A

HISTORY

OF THE

PYRITES,

THE

Principal BODY in the MINERAL KINGDOM.

In which are considered its Names, Species, Beds, and Origin; its Iron, Copper, unmetallic Earth, Sulphur, Arsenic, Silver, Gold, original Particles, Vitriol, and Use in smelting.

The whole compiled from a Collection of Samples; from visiting Mines; from an intercourse and Correspondence with Naturalists and Miners; but chiefly from a Course of Chymical Enquiries.

With a PREFACE, containing an Account of the Advantages arising from Mine-works in general, and particular from those of *Saxony*.

Translated from the *German* of

J. F. HENCKEL,

Late chief Director of the Mines at *Friberg* in *Saxony*.

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1757

(V,

Gift of
C. G. Weck

An Explication of the Frontispiece.

1. IS exhibited a ſulphur hut, with the reverberating furnace and retorts, in which the ſulphur is driven or forced out of the Pyrites.

2. In the vitriol hut is repreſented the leaden pan, in which the vitriol is boiled out of the Pyrites, together with a waſhing trough.

3. In the third hut, the deſulphurated Pyrites is lixiviated, and prepared for making vitriol.

4. In the arſenic hut ſtands the reverberating furnace, with the diſhes and ſubliming veſſels out of which the arſenic is forced.

5. A coe or hut over the mouth of the ſhaft.

6. The mouth of a level.

7. A ſhaft, with the windlaſs, all having a relation to mining.

And as hot baths, vulcano's, and whirlpools, derive their matter from Pyrites and ſulphur, ſomething about them is alſo exhibited.

ADVERTISEMENT.

DR. Henckel's book on the Pyrites is in the highest esteem with all lovers of mineralogy; both, on account of the subject; a leading body in the mineral kingdom, analysed into its constituent parts; with the use and importance of these parts at the same time fully displayed: and on account of the method of treating it; as a pattern worthy of copying after in our enquiries into nature, and a just specimen of the method of induction.

Nor is the whole less instructively interspersed with several fine and important observations in mineralogy, chymistry, assaying and smelting.

A translation, therefore, of so useful a book, it was hoped, would meet with a favourable reception from those who are lovers of a solid knowledge of nature, the genuine result of observation and experiment.

Dr. Henckel, however, though in other respects so excellent an author, is certainly but an indif-

ferent writer; diffuse to a fault, and generally very obscure and perplex in his manner of writing; with respect to which he has here been attempted to be abridged, cleared up, and unfolded: but his strain of low pleasantry and affectation of learning have been entirely dropt, as quite foreign, and consequently without any detriment to the subject.

Where the author, in the course of the work, has omitted to explain a term of art; or, where any particular circumstance seemed to require a further illustration, a note has been added at the bottom of the page, in order to render the book as intelligible as possible.

With respect to this translation, much of the accuracy thereof is owing to a gentleman of uncommon eminence in this sort of knowledge, who was pleased to take upon him the revisal of the sheets.

THE

Author's PREFACE.

THE following particulars serving to shew the advantages accruing from the business of mining, both to the public, and to particular persons, may not be altogether unacceptable to the reader. As,

1. That the chronicles of Friberg and Misnia furnish us with extraordinary accounts of considerable *tenths* and profits, consequently of the great advantages arising from the Misnian mines, both to the prince and undertakers. In particular, that Henry the Illustrious, marckgrave of Misnia, had in the 13th century, from the mines of Friberg and Schneeberg alone, procured so many *tons of gold* * in silver, as enabled him to purchase the

 king-

* A ton of gold is a method of reckoning money by; which in a country reckoning by dollars or florins, amounts to 100000 dollars or florins, &c.

kingdom of Bohemia *. Further, that the weekly *tenths* from Friberg alone amounted in the fourteenth century, to 5000 rix-dollars, making in all a yearly income of 260,000 rix-dollars. The profits, therefore, to the adventurers, which amount to nine times as much, muſt have been 30 *tons of gold* †. And though ores may riſe and fall in value, they notwithſtanding yield a conſiderable income ſtill.

From 1529, to 1630, a period of one hundred years, when the ſchedules were firſt publiſhed, the profits to the adventurers from Friberg alone, amounted to thirty ſeven *tons of gold.* At Schneeberg, from 1470 to 1510, a period of forty years, to forty *tons of gold.* At Anneberg, from 1496 to 1626, a term of one hundred and thirty years, to thirty ſeven *tons of gold.* At Marienberg, from 1520 to 1627, a ſpace of one hundred and ſix years, to twenty four *tons of gold.* So that within the compaſs of one hundred years, taking one place with another, the total amount will come to ſeveral millions: and then it would be no difficult matter to make a calculus of the *tenths*, mintage, &c. falling to the ſhare of the prince.

From an old written abſtract it appears, that from 1590 to 1626, a ſpace of thirty ſix years, the

* Meiſniſche Berg-chronicke, p. 35.
† Freybergiſche chronicke, p. 431.

the *tenths*, the mintage, the duties from the huts, from the works of draining § and battery ‡, after deducting the profits for the adventurers, come to above twenty-four *tons of gold*; and thus to a yearly income for the prince of almost a *ton of gold*. Whence we may easily see what the profits to the undertakers were. From 1603 to 1622, a period of nineteen years, the smelting huts of Friberg brought in to the electoral chamber above 100000 florins: the works of battery, and the duty on coals and wood, in the territory of Schwartzenberg, from 1590 to 1620, a space of thirty years, above 150000 florins: the cobald and smalt works, from 1611 to 1623, above 100000 florins: the mintage of the burnt or fined silver of Friberg, from 1620 to 1623, and thus for three years only, above 800000 florins: the mintage at Anneberg, Marienberg and Schneeberg, after a deduction of the profits, for those three years, above 60000 florins.

And did we consider each groove and mine apart, many of them would be found to yield the like princely, nay royal income. To instance only

§ Draining at the huts, is the operation of separating the silver from the black copper, or the sort not quite freed of its sulphur, and other impurities. It is performed by smelting together a quantity of black copper and lead, and tapping them off into round cakes, which being set edgewise in a peculiar furnace, and exposed to a gentle fire, suffer the lead, carrying along with it the silver in the black copper, to drain or trickle from them, leaving the copper honey combed and spongy.

‡ The operation of beating out iron into bars and plates.

only in the fixteenth century: It appears by the Friberg chronicle *, there were above one hundred fuch works, which yielded quarterly, in profits to the adventurers, for one mine-action (according to the then divifion into thirty two fhares) at the leaft ten; moft of them above thirty and forty; many above fifty and one hundred; nay, fome, above two hundred; and the Thurnhoff and Hohebircke in particular, above three hundred rix-dollars. And this we fhould well obferve, as it fhews, that not only one or two mines, are thus valuable, but generally all of them; and obviates an objection, as if all thefe treafures were now quite exhaufted: which is far from being the cafe; our hopes being ftill as extenfive, as there are grooves and mines to work, and *field* for receiving fuch a vaft number of fhafts and levels †: not to mention entire, *unmeafured* veins, which are fo much frefh and unoccupied treafure.

Further, the accounts and inftances we have of extraordinary rich ores in fome works, fhould prevail with us to view the bufinefs of mining with other eyes than we commonly do. At Schneeberg in 1478, a rich filver vein was dif-

* P. 434. † Shafts are pits, fometimes perpendicular, fometimes oblique, funk upon a vein. Levels are horizontal paffages worked thro' a mountain, both for draining the mine of its water, landing the ore to the day, and for conveying in air. And for both thefe laft ufes fhafts alfo ferve.

discovered, and so large a wedge or block of ore, and native silver laid bare, that duke Albert of Saxony went in person down into the groove, and used this huge block, which smelted four hundred centners of silver, as a table to dine on *. And tho' such huge masses are uncommon, yet it is not unfrequent to see exposed at once, even within a narrow compass, large quantities of ore, as might, were a calculus made, come to several centners in silver. For not to mention masses of native silver, and of *glassy* and *red-goldish* ores, we find, at the proper depths, large veins of *lead-glitter*, or galena and the like ores. Nor is it at this day unusual at Schneeberg, Johan-Georgen-stadt, Ehrenfriedersdorff, and the like noble mines, to discover whole nests of native silver, *glassy* and *red-goldish* ores, delivered into the smelting-huts by centners †.

2. That mines, as we have seen, constitute not the least, nay rather the principal branch of a prince's revenue, when once they are brought to bear, and have a proper demand on them; the tenths alone making no inconsiderable part thereof.

3. That the advantages, indirectly or mediately, accruing to a state from mines are very great: in that they serve to support and increase the num-

* Albini Meissnische Berg-chronicke, p. 30.
† The mine-centner is reckoned at 110 lb.

number of inhabitants, afford the materials for trade and manufactures: and what we should principally here consider, the consumption of home and inland commodities, all yielding duties and taxes: by which means at least money comes to circulate longer in the country, and not fall into hands, that either hoard it up, or send it abroad for commodities, we may well be without. And it must be a standing proof of the value of mines to a country, when we read of whole cities and towns being built by their means: as it is to them alone, that Friberg, one of the most considerable in Saxony, owes its rise and present flourishing state, being, no earlier than the thirteenth century, but a poor despicable village, still constituting the most inconsiderable part of the town at present, and called the Saxon-town. Schneeberg, which comes next to Friberg; nay, all the mine-towns in general, owe their rise to mines. And Johan-George-stadt, founded by the elector John-George, I. is a peculiar instance, that our country, even in latter times, is as capable as ever of having its mine-works improved, and brought to a flourishing state.

4. That the business of mining has, in our country at least, no small degree of preheminence above all others of what denomination soever. There is not a greater demand for any one thing than for the produce of mines; and yet nothing is rarer in any country. No country is without manufac-

nufactures; but many, without mines; most without serviceable ores; many, especially on the score of situation, scarcity of wood and water, unfit for carrying on the business of mining. In a word, mines are, as it were, a privilege peculiarly bestowed on some countries, exclusive of others, and therefore to be highly esteemed. But to conclude, what are all the subjects of the grand manufactures in Misnia other than those supplied us by mines? For instance, the famous smalt-work at Schneeberg, which has yielded so many millions both to the prince and adventurers, is no where in the world to be matched, and consequently to be deemed a peculiar treasure. Our salt-springs too are a kind of mines. Tin is a metal become very necessary in common life, and yet, in some measure, the rarest of all others. There are but few tin-mines in Germany; nay, in respect of other metals, few in Europe. All in Germany, as far as I know, are those in Misnia, Bohemia, and Carinthia, and formerly in the Fichtelberg at Wonsiedel. Whole kingdoms, as Sweden, Denmark, Norway, &c. have no such mines, but are obliged to be supplied with tin from England: and all Germany, from Misnia, Bohemia, and England too.

5. That our Misnian mines in particular have by far the preference to all others in Germany. Two things, namely *levels* and wood, are indispensibly

penſibly neceſſary for carrying on a mine-work. The former, in order duly to reach home to the proper depth, and through ſuch ſubterraneous canals to drain off the water into a valley; in order thus to ſuperſede the uſe of expenſive engines. The latter, in order not only to timber and ſecure, where needful, the *ſhafts* and *drifts* *, but alſo ſmelt and work the ores for their metal. Now, as to *levels*, our forefathers have, for inſtance at Friberg, left us ſuch extraordinary works in this kind, as that, in want of them, our mines would become quite impracticable; particularly that called the *prince's level*, one of the grandeſt works in theſe parts, conſidering the time, labour and expence neceſſary to work a paſſage under ground through firm rock, for about five Engliſh miles in length. As to *wood*, the want of that in particular diſqualifies many places for mining. The expences at the *day* in aqueducts, trenches, ſtamping and waſh works, in engines, in conſtructing the ſmelting and other huts, in wooden trunks, good *additions* † or fluxes, ſerviceable *ſlags* or ſcoriæ, &c. Things abſolutely neceſſary in the buſineſs of ſmelting, come very high in ſome places, but not ſo in Miſnia. Nor muſt I omit mentioning to our honour, that both for

* Drifts are horizontal paſſages, much in the nature of levels deſigned either for going upon a vein, and digging out the ore; for conveying off the water, or for conveying the ore to its place of collection, or the bottom of the ſhaft.

† By additions ſmelters mean thoſe matters added to their ores, in order to procure their yield, or to work them to better advantage.

for the businefs of mining and that of fmelting, we have the ableft, moft experienced and ingenious artifts in the whole world: nor this other confiderable advantage, peculiarly our own; namely, the variety of our ores, than which nothing is more ferviceable in the bufinefs of fmelting: as by properly dofing and mixing thefe together, we are able to work to better advantage what would otherwife remain unfmelted, and be forced off among the *flags.* And who could ever have imagined, that *redgoldifh*, and the like rich ores, fhould fail to fmelt, if not worked with *pyrites?* And yet this is what for fome years paft our neighbours at Nicolas-mine in Bohemia have fufficiently experienced: whence they are obliged, at much expence and labour, to be fupplied with the *pyrites* from us; in order previoufly to *crude-work* their poor, *quartzy* ores: that is, fmelt them crude along with defulphurated *pyrites.*

My view in all this is to fhew of what confequence the knowledge of ores, or the bufinefs of mineralogy is as a foundation for thofe of mining and fmelting: and that a very ferviceable, important fubject is the matter of my prefent enquiry.

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PYRITOLOGIA:

OR, A

HISTORY

OF THE

PYRITES.

CHAP. I.

The Subject propounded, with the Manner of treating it, &c.

AT length appears this promised history of the *pyrites*. And considering the length of time I have been employed in it, many of my readers might, perhaps, expect a larger work on the subject, and to have had it sooner. To such I offer the following reasons by way of apology.

1. A multiplicity of avocations: my station and circumstances in life being such, that many times for half a year together I have not been able to bestow so much as a single hour upon

 the

the ſubject, either as a chemical operator, or as a writer. Tho' indeed, to be ingenuous, ſomething of diſguſt and indifference interpoſed; as generally is the caſe in a work of conſiderable length, and carried on amidſt a diſſipation of thought. Neverthelefs, ſuch as it is, I have ſpent ſo much time and been at ſo great expence in this performance, that I know not whether, under the ſame circumſtances, I ſhould ever again be able to execute ſuch another.

2. The importance of the ſubject: more than a little time was required to procure from the ſeveral countries and mines their ſeveral ſpecies or ſamples; and the Engliſh ſamples, diſpatched for me by the celebrated Dr. Woodward, never came to hand. A repetition of ſome experiments was alſo neceſſary, eſpecially to determine the very ſlow vitrioliſation of ſeveral ſorts of *pyrites*, further to confirm my opinion of this mineral body, and to procure the remarks and ſentiments of my correſpondents concerning it.

3. My method of treating the ſubject: it was not my intention to fill up my book with tranſcripts from authors. Nor indeed had I ever ſo great a mind to it, could I well; ſeeing nothing uſeful to my purpoſe could be found in them.

But is it readily to be imagined, that the treating a ſubject in the laboratory, and the diſcovering a new truth, ſhall require no more time than the writing over a few leaves of paper? I may truly aver, there is many a truth and many a very ſhort propoſition, which I was obliged to retain in my thoughts, through the courſe of this enquiry, as it were in labour, to bring them to the birth, here ſet down in the compaſs of a few lines, that employed me not only days and Weeks, but even months to aſcertain. And yet, after all, ſome others remain behind,

on

on which I might have ſpent a great many years, or even my whole life, and not be able at laſt to place them in a clear light, and free from every objection.

One of my views in this undertaking was to ſet a pattern to others, who may happen to have better helps, than I can well challenge, to proſecute this ſubject to a greater length. Another, to engage the attention of mankind in the ſtudy of nature: a ſolid and uſeful knowledge of which is rather to be hoped for in this manner, than from the books commonly wrote on the ſubject. But from this track we are generally diverted, either by our preſent method of education, conſiſting for the moſt part in learning the application of lines and angles, as the neareſt ſtep towards the attainment of the knowledge of bodies, whereby we entirely diſregard the ſtudy of nature in herſelf; that is, in the forms, mixtures, and qualities of bodies; tho' by far the moſt important and uſeful. Or, thro' a remarkable degree of indolence, notwithſtanding the pleaſure attending the purſuit, chuſe to forego the trouble, generally accompanying the making proper experiments and obſervations; eſpecially proceſſes by fire, where every circumſtance is to be regiſtered, or ſet down with the greateſt care, and accompanied with proper remarks. Nay, where a ſingle over-ſight, the ſpringing of a glaſs, or even a groundleſs ſcruple, after the proof or trial is over, may occaſion the repetition of an experiment, perhaps, ſeveral times. Tho' this very trouble is abundantly compenſated, by the ſolid knowledge and experience we derive from thence to ourſelves: hereby we have a lively and clear conception of things, in caſes where books prove uſeleſs, nay fallacious; and are enabled to pronounce with boldneſs and certainty concern-

ing the truth or falſhood of any propoſition. Nay, even the very noting down the ſeveral circumſtances of a proceſs muſt be advantageous, by affording a conſtant directory for repeating the experiments afterwards, without any fear of a miſcarriage: and the comparing one truth or axiom with another, cannot fail to yield us juſt and ſolid concluſions, as well as the beſt materials for laying the foundation of a ſolid natural knowledge.

A principal motive to the preſent undertaking, in which I could wiſh to be imitated, is the improvement of natural hiſtory. A perſon, converſant with things, and not with books only, muſt needs experience the inſufficiency of our preſent philoſophy, and how few ſubjects are treated by writers with accuracy and preciſion enough, to give full ſatisfaction to an inquiſitive mind. Inſtances of their negligence, in this reſpect, are every where obvious; but no where more ſo, than on the ſubject of the *pyrites*; no one author having hitherto ſupplied us with any clear deſcription, or tolerably accurate diſtinction of this important and leading mineral body. I ſay not this merely with a view to find fault, being rather inclined to commend the care and diligence of thoſe, who have gone before me: nor do I preſume to ſet up my own performance for faultleſs and finiſhed; but to expoſe the indolent methods of thoſe writers of our days, who content themſelves with being mere tranſcribers. In our enquiries after truth, we ought to uſe a freedom and openneſs in animadverting upon the imperfection of our knowledge: Nor ſhould we ſtop ſhort with the ancients; but taking up one body after another, conſider each with due attention and leiſure, and thus collect materials for lateſt poſterity to work upon, and there-

with

with raiſe better ſyſtems than we are at preſent poſſeſſed of.

Of what conſequence chemical enquiries into nature may be, will appear from ſome diſcoveries I have accidentally made, in my examination of the *pyrites*; from which, and a certain kind of earth, each ſeparately barren of ſilver, I procured an actual ſilver: alſo from *pyrites* itſelf, a ſteel tincture peculiarly ſweet, and without that roughneſs, common to ſuch tinctures; alſo from my enquiries into the nature of the *pyrites*, I have gained no ſmall degree of knowledge in the buſineſs of ſmelting ores.

As to my method of procedure in the preſent enquiry; I have, in the firſt place, laid it down for a rule to myſelf, to abide ſtrictly by matters of fact, without giving into any hypotheſis or empty ſpeculation whatever; and, therefore, I attempt not to ſeparate or reſolve the *pyrites*, either into the four elements, the three, or other imaginary principles; as being things that can never be made objects of our ſenſes; or that any one can ſo explain, as to convince an impartial enquirer, that theſe are the eſſential conſtituent parts of our ſubject: a rule as indiſpenſibly neceſſary, as it is generally but little regarded. 2. I have put the *pyrites* to ſeveral accidental proofs, and by that means often diſcovered, what I otherwiſe could never have hoped for. That from the acid vitriolic-ſalt, and the alcaline earth of the herb Kali or Soda, a blue colour ſhould be procurable, is what no one could beforehand ſuſpect: as little, as that the *pyrites* ſhould yield a ſweet iron-tincture; or, that a ſpecies of earth, in itſelf deſtitute of ſilver, ſhould, by means of the *pyrites*, become remarkably ſilvery. 3. I never ſcrupled ſeveral times to repeat a ſingle experiment; either up-

on the breaking of a veſſel, or other failure in the courſe of the proceſs. 4. I have uſed the greateſt care in chuſing and ſeparating the ſeveral matters employed; a circumſtance of no ſmall importance; for, not to mention the various ſorts of ſolvents, ſalts, *&c.* (which notwithſtanding are to be well examined in reſpect to their goodneſs; ſo as we may be able to diſtinguiſh, for inſtance, between alcali and alcali, ſalt of tartar and potaſh) we muſt be careful, knowingly not to employ for proof any communicative *additions*, but the bare *pyrites* alone. The ſeveral ſamples employed, were ſuch as I either originally procured myſelf, or had from perſons of credit and veracity. Theſe I carefully examined and ſeparated from each foreign admixture: which was found needful, even when externally they ſeemed to give no ſuch ſuſpicion; as is plain from the *ſteely* or cloſe *pyrites* of Pretzſcendorff; having experienced the ſeemingly pureſt ſort of them, to be not only internally full of fiſſures, or fibres, but theſe fiſſures to be often mock-leady, and thus apt to miſguide or at leaſt to puzzle the moſt careful operator. And the *pyrites-kidnies* of Franckenberg, how cloſe ſoever they may ſeem externally, and how ſimilar ſoever, internally, yet ſhew not only a black mock-leady impurity, but alſo ſuch interſperſed pieces of *copper-pyrites*, as are evidently diſtinguiſhable from the reſt of the ſample, namely, the genuine *iron-pyrites*. 5. A no leſs degree of care I uſed with regard to the veſſels and inſtruments, employed in making the experiments: a caution of greater importance than the unexperienced may imagine. The colours manifeſting themſelves in experiments, ſhew much of the internal nature of bodies, and their productions: or, at leaſt, how one ſort comes to differ from another; and are of ſo peculiar a nature,

as

as that a ſingle drop of a foreign liquor, or the leaſt grain of a ſalt, or ſmut, ſhall change them: and therefore, to procure ſuch as are beautiful, the greateſt nicety and care are to be uſed, as in this caſe, having to deal with one of the moſt delicate ſubjects in nature. Nay, mixtures themſelves come out very different, without the greateſt care be had to make perfectly clean a veſſel once uſed, or to employ a new one; a little common ſalt, or ſal ammoniac, directly adulterating aqua fortis; the leaſt quantity of a contrary ſalt marring an intended fermentation; and a lixivious ſalt, which has conceived only a little acid from the air, becoming unfit for the mercurification of metals, as well as for other proceſſes. And in the buſineſs of aſſaying, there may ſomething, which may ſerve to falſify a proof, ſtick to the ore-diſh, or to the hammer, wherewith the proofs are rubbed, or even to the hare's foot. And in the deſulphuration of the *pyrites*, we might, without uſing new retorts, nay, even new receivers, eaſily be impoſed upon, or at leaſt, not ſo certainly obſerve what *pyrites* are, and are not, arſenical; as the arſenical impurity may unobſervedly lodge in retorts and receivers, not ſufficiently cleared thereof; nor will the fetid arſenical ſmell, very ſoon wear off; whence alſo the weight of what paſſed over, and what remained behind, cannot always be taken with a neceſſary exactneſs; a circumſtance, to be well obſerved. 6. Another direction of moment, is the accurately entering the ſeveral experiments into a particular journal; the numbering the ſeveral glaſſes, boxes and caſes, for holding the different matters to be worked, and the ſeveral productions procured; either for a farther examination, or future uſe.

And though the *pyrites* be a mineral ſo very common, that there is ſcarce any earth, ſtone,

fibre or vein without it, and of ſuch extenſive uſefulneſs, ſupplying us with ſulphur, arſenic and vitriol, thoſe capital inſtruments both in nature and chemiſtry, and with one of the moſt powerful fluxes (eſpecially with us in Germany) for forcing ſtubborn ores to give forth their contents; yet its nature is hitherto ſo little underſtood, and all the accounts we have of it are ſo very lame, no one having either clearly deſcribed, or accurately diſtinguiſhed it, that an attempt to put it in its proper light ſhould ſeem to want no apology.

But to give the reader a ſtill nearer view of my manner of managing this ſubject: I have examined upwards of 60 different ſamples of *pyrites*, procured from different parts; conſidered each ſample apart in its colour, texture, and ſpecific gravity; expoſed a little of each to the air, in order to diſcover which ſort would, and which would not, be affected and opened by it; to the fire, for its contents; to the action of the magnet for its iron, both in the crude and calcined ſtate of the ſample; to aqua fortis and aqua regia, for the gold and ſilver; nay, to vinegar and ſpirit of ſal ammoniac, for diſcovering the copper in it: ſome ſamples I have boiled with alcaline lixiviums, with lixiviums of common ſalt and allum; the one to ſeparate the ſulphur from its metallic earth, and form a *hepar ſulphuris*; the other, for the vitriol acid to lay hold on the alcaline earth, and diſcharge the acid of the common ſalt; conſequently to exhibit an Epſom, or the like ſalt of a mineral water, or a Glauber ſalt; and thus to ſerve to eſtabliſh my conjectures on the original of *acidulæ*. I have combined the ſeveral parts of the *pyrites* with each other, and with other bodies; nay, the entire *pyrites* itſelf. I have examined the *capita mortua* of the *pyrites*, in the ſame manner as the *pyrites* itſelf: in particular, I have mixed

the *pyrites*; ſometimes with ſal ammoniac, whereby I have procured the ſaffron iron-flowers; ſometimes I examined it by detonation with ſaltpetre, in order to find out the different proportions of its inflammable earth: and laſtly, took a great deal of pains in aſſaying it, by employing, as *additions*, various ſorts of earths and ſtones.

Volcanos and *Thermæ*, are, in a great meaſure, owing to the effects produced by the *pyrites* in the bowels of the earth. As it is well known that iron and ſulphur perfectly, and with eaſe, take fire along with water. By means of theſe it was, that the elder *Lemery* attempted, in the ſmall way of experiment, to imitate the effects of volcanos and earthquakes. And for this purpoſe he ground iron and ſulphur, which, with water, he made into a paſte; which, after ſtanding for two or three hours in the open air, began, without any application of fire, to grow remarkably warm, then hot, at length to heave and ferment; and thus the maſs, in ſeveral places up and down its ſurface, came to have ſeveral cracks and rents, thro' which there tranſpired a fume, which proves only warm in ſmaller, but actually takes fire in larger maſſes, as of thirty or forty pounds. From this experiment he attempted to account for the burnings of *Veſuvius*, *Ætna*, *&c.* And with that view he proceeded as follows. "I put, ſays he, "ſome of this mixture of iron and ſulphur, both into larger and ſmaller, and into taller, narrower "pots; and the matters, as lying there more "cloſe and confined than in earthen diſhes, became more violently heated and heaving, and "in part ſprung out of the pot. Further, in "ſummer-weather I filled a large pot with fifty "pounds of this matter, and covering the pot "with a linnen-cloth, buried it about a foot deep

"in

"in a hole in the earth, and covered all with "earth. In about eight or nine hours after, the "earth beginning to heave, heat and ſpring up, "there burſt out a ſulphureous hot fume and an "actual flame, which enlarged the rents, and a "yellow black powder ſettled ſuperficially round "about them. The earth remained a long time "warm: and when I came, after this, to dig "out the pot, I found remaining only a black heavy "powder, &c. This proceſs ſucceeds better in "ſummer than winter, as the ſun's heat may "be ſuppoſed to have a better effect on the ſul-"phur and iron." He then proceeds to obviate ſome objections. As, 1. Whence volcanos come to have their air, without which there can never happen any accenſion. 2. How amidſt much moiſture, as the water of the clouds, the matter of thunder and lightning, ſhould come to take fire: as to the firſt, 'tis eaſy, ſays he, to conceive that the earth, a porous, permeable body, is equally filled, as it is invironed, with air. The ſecond he endeavours to explain by means of that experiment, where, in making iron-vitriol with the acid of vitriol and common water, the fumes ariſing from the glaſs body take fire, and burſt out into actual flame, by approaching a candle to them, as though they were ſpirit of wine, notwithſtanding theſe inflammable ſulphur-particles are envelop'd in water *.

Laſtly, As to *Thermæ*, or hot ſprings, I imagine no one, acquainted but ſuperficially with their internal conſtitution and nature, will call in queſtion their partial orgination from the yellowiſh or ſulphur-iron *pyrites*; I ſay *partial*, and not *total* origination; in regard that theſe, in particular the *acidulæ*, as the *Caroline*, &c. carry along with

* Mem. de l'Acad. Roy. l'ann. 1700, p. 131. *Seqq.*

with them ſome highly predominant and capital matters, namely, a lixivious ſalt, and a calcarious earth, which cannot be ſuppoſed to be derived from any one ſort of *pyrites*; but probably, if not from common ſalt, from lime-ſtone; and if not from this laſt, from ſpad, which is a calcarious ſort of ſtone; and if not from ſpad, from ſo fatty an earth and ſtone, as that from which the aluminous lime-earth is generated. For, who is not convinced that theſe ſprings generally contain ſomething vitriolic, which remaining untouched by the lixivious ſalt, exhibits a formal vitriol; or, in other words, its acid ſalt may be made to ſeparate from the alcali; and thus form a bitter ſpring-ſalt, its metallic earth falling as an ochre to the bottom. And ſulphur itſelf formally effloreſces about ſuch mineral ſprings, as thoſe of *Aix-la-Chapelle* in particular. Now ſulphur, the vitriolic acid, and a metallic ochre, are parts derived from *pyrites*, and not from ſtone-coal or bitumen.

CHAP.

CHAP. II.

Of the NAMES* of the PYRITES.

IN natural hiſtory, and more eſpecially in the foſſile kingdom, fancy rather than judgement appears to have determined the names of a great variety of bodies: thus to imaginary or accidental circumſtances the *Dendritis*, *Selenites*, *Myrrhinites*, *Ætites*, *Aſtroites*, *Bufonites*, with many more, owe their reſpective denomination. With reſpect to the mineral under conſideration, its name, *pyrites*, or fire-ſtone, has, above moſt other foſſils, the good fortune to be equally juſt and expreſſive.

It is called a ſtone in the ſame ſenſe, as all ores, that are not quite ſpungy and friable, are ſo denominated from their hardneſs, weight, and cloſeneſs; for inſtance, *lapis æris*, *lapis ferri*, copper-ſtone, iron-ſtone, &c. however, we are not to confound it with the *horn-ſtone* [flint] which is uſed for fire-arms, and at this day commonly called by the Germans *fire-ſtone*.

Pyrites more eſpecially derives its name from fire, as it contains a larger ſhare of ſulphur, which is the *pabulum* of fire, than moſt bodies in the mineral kingdom: not indeed more than all ores, ſeeing cinnabar and antimony ores, alſo ſtone-coal, partake conſiderably of ſulphur; nevertheleſs, it claims a preference in this reſpect to all ores of a ſtoney nature, which the three abovementioned cannot be properly deemed, on account of their friability, and extreme looſe texture. In

* It is but juſtice to the author to take notice that, under this head, he has ſhewn great aſſiduity, and diſplayed more than a common ſhare of learning, in tracing the Etymologies of the ſeveral names applied to *Pyritæ*. Theſe, however curious, are apprehended not the moſt uſeful parts of this work; for which reaſon the tranſlator acknowledges that he has taken greater liberties in his abridgement of this chapter, than in any other.

In High-Dutch *pyrites* is called *kies*; whence this term is derived is not very easy to determine; perhaps the first inventor of it had in view the *kiesel*, or flint-stone, as *kies* and *kiesel* are so far analagous in that both strike fire: or it may well enough be derived from *erkiesen*, to chuse, as that stone or rock is, in mining, to be *chosen* before all others, where such a sulphureous vitriolic iron and copper ore offers, seeing the *kies* can lead the miners, as by a clue, to the wished-for labyrinth of gold and silver veins: also, when two undertakers have branches of veins running together, and afterwards separating, and coming out of the compass of the share, the elder must *chuse*, or pitch upon a branch, which he cannot readily do without *kies* †. But should neither of these derivations be approved, it yet may be allowed to pass for a venerable old German mine-term, till its genuine etymology can be ascertained. It is at least so common a word among Germans, that I know of no province, in which the language is spoke with propriety, where it is not in use; only with this difference, that some are not accustomed to apply it to such *pyritæ* as are very coppery, or highly arsenical: for instance, at Friberg, the former are called copper-ore, the latter *misspickel*; with these the term *kies* is wholly dropt; while others, particularly at the Hartz, are wont to call even the richest copper-ore *kies*, as, *copper-kies*.

The Arabians use to this purpose the term *marcasita*, marcasite, which the Germans also have, from the Romans, in some measure, adopted. This appellative, though, strictly speaking, it is not, under certain circumstances, improperly applied to the subject here treated of, has been made use of, by different authors, to denote such a vast variety of mineral substances, as well artificial as natural,

† *Rosiler*'s Berg-bau Spiegel [Mine Mirror] l. 4. c. 4. § 14.

natural, that it ought not to be received but with ſome caution, and under many reſtrictions. The druggiſts ſeem to underſtand by it *biſmuth*, and the alchymiſts, who indeed generally affect confuſion and obſcurity, have made it to expreſs not only *biſmuth*, but alſo *regulus of antimony*, *ſpelter*, and moſt of the known ſemi-metals. Among the mine-men, particularly thoſe of Miſnia, by *marcaſite*, according to the beſt information I could get, is meant our *pyrites*, or *kies*; not generally, but only when finely angular, ſmooth, and eſpecially of a cubical form, and of a gold-glittering caſt. On the contrary, another, though broke off from this very piece, which in the freſh break has the very ſame colour, and which affords the ſame contents, if it happens only to differ in the external figure, is not, on any account, allowed the name of *marcaſite*.

Under the like circumſtances of confuſion and ambiguity, the term *Magneſia* has been introduced into the hiſtory of the *pyrites*; particularly by alchymical writers, as Flamellus *, who gives this denomination to the *pyrites Achaiæ*; and Bohnius † uſes the ſame expreſſion (with the addition of *Vitriolata*, on account of its eaſy reſolution in the air) to denote the Heſſian iron-earth, which is a real, and indeed a firſt-rate *kies*. However, among mine-people, and in common language, the term is very little, if at all known, except with the glaſs-makers, who mean by it a martial mineral, more commonly called brown-ſtone, of a duſky colour, rather inclining to black, and ſpicular, like antimony. Its uſe in the glaſs-houſes is to give a due whiteneſs and tranſparency to the better ſort of glaſs: the potters alſo employ it in glazing their manufactures. In Italy it is known by the name of *Manganeſe*. But though the word *Magneſia* is not

* Theatr. Chym. T. IV. p. 863.
† Bohnii Diſſert. Chym. IV. p. 108.

not generally made uſe of, and has often been injudiciouſly applied, to ſignify *pyrites*, if it be conſidered, that many ſpecies of *pyritæ* powerfully attract the air, which is the moſt natural ſort of vitrioliſation, this appellation, derived from their *magnetical* quality, will not appear altogether unjuſt, or improper.

Bernh. Cæſius §, and Feſtus Pompeius, ſeem to have been deceived by appearances, and to have meant a *pyrites*, by what they have called an *Aurichalcum foſſile*, or a native foſſile braſs. Ulyſſes Aldrovandus ‖ has clearly diſcovered the miſtake of the latter; a miſtake, that nothing but a profound ignorance in mineralogy could have occaſioned.

Igniarius, *lapis luminis*, fire-ſtone, light-ſtone, are names more juſtly appropriated to *kies*, or *pyrites*; ſeeing by a ſmart ſudden ſtroke againſt ſteel, they emit ſparks of fire and light, that manifeſt themſelves by the accenſion of gunpowder, tinder, or ſuch matters. However, *pyritæ* differ in this reſpect, according to their contents; thoſe that partake moſt of copper, afford the feweſt ſparks, and by how much more they are impregnated with iron and ſulphur, the moſt; though even the white arſenical *pyrites*, or *miſſpickel*, that yields no ſulphur, will exhibit ſome fire.

From hence the Germans have given to *pyrites* the name of *Buchen-ſtein*, fire-lock-ſtone, as it was formerly uſed for fire-locks: but in order more effectually to anſwer this purpoſe, care ſhould be taken to chuſe ſuch as are the hardeſt, moſt denſe, and capable of being worked into a proper form.

Mart-

§ L. I. c. 9 p. 130.

‖ Quando Feſtus Pompeius ſcripſit *aurichalcum* in montibus naſci, proculdubio non eſt locutus de aurichalco, arte parato, quod ex ære et cadmia conficitur, ſed fortaſſis hunc *Pyritem* intellexit, qui aurichalcum perbelle æmulatur. Aldrov. Muſæum, L. VI. c. 3. p. 514.

Mart-ſtein is another denomination of *pyrites*, and far from being attended with any impropriety; as its etymology may be deduced from *Mars*, or iron, and this foſſile is principally an actual iron-ſtone.

Vulcan, the god of fire, being under great obligations to the *pyrites* for his beſt fuel, as appears from thoſe huge elaboratories in mounts Hecla, Ætna, and Veſuvius, the ſubject of our preſent enquiry has been honoured with the title of *Hephæſticus*, or *Hypeſtionus*.

As iron makes a principal part in the compoſition of the *pyrites*, *ſideritis*, σιδηρίτης, iron-ſtone is no inadequate appellation; nor, if its igneous qualities are duly attended to, can *pyropus*, *pyrobolus*, *pyrimachus*, terms uſed by ſome of the antients to ſignify the ſame thing, be thought very improper.

Othonna, according to Geſner, is a copper-coloured ore in Egypt, which Aldrovandus takes to be the ſame with *lapis luminis*, and Ariſtotle's *pyrimachus*:—*Atrament-ſtein*, or vitriol-ſtone, has alſo been numbered among the denominations of *pyrites*; but of this laſt appellation more hereafter.

Corallus, coral-ſtone ſeems to be miſapplied, when appropriated to *pyrites*, ſeeing though the rock wherein it lies is often found red, the genuine *pyrites* never exhibits that colour.

Chalco-pyrites is an uſeful diſtinction of the coppery ſort: nor is the *aſſius lapis*, or as Agricola expreſſes it, *Aſiæ lapis ſive lapis ex Aſia, ubi naſcitur ſarcophagus*; that is, where the fleſh-conſuming ſtone grows, altogether improper, as the corroſive power of vitriol is well known.

But it is high time to have done with mere names; let us proceed to what it is hoped will afford more real inſtruction, which, to the utmoſt of my ability, is intended in the ſucceeding chapters.

CHAP.

CHAP. III.

Of the several SPECIES of the PYRITES.

PYRITES, or *kies*, in the sense we are to take it, is a mineral or ore, partly white-grey, partly yellowish grey, partly brass-yellow; having for its constituent principles a metallic, namely, an iron earth, which is its proper characteristic; a volatile matter, as either sulphur or arsenic, or both, tho' the former prevails more frequently; some sorts are found to partake largely of copper, with which is generally found a mixture of silver, but in a very small quantity, and sometimes an appearance of gold, tho' this is rather imaginary. The *pyritæ* are commonly worked for sulphur, arsenic, sandarach and vitriol, the last of which ought not to be looked upon as an original principle, but as a production consequent of the combination of the other principles.

The parts of the *pyrites* may also be considered as they are either essential or incidental. With respect to the former, there is properly in nature no more than one sort of *pyrites*; for in all there is iron, and this iron is the primary constituent part; every *pyrites* being an iron earth, either sulphurated, or arsenicated, or participating of both at the same time. In an incidental view, *pyrites* are distinguished, 1. with regard to their metallic contents. 2. Their sulphur and arsenic. The former may be divided into iron and copper *pyrites*, the denomination being here taken from what constitutes the greatest part of this composition. At Friberg, the *copper-pyrites* denote such as yield

one, two, or the like ſmall number of pounds of copper, and called at Friberg *copper-ore.* Thus were *copper-pyritæ* diſtinguiſhed by a peculiar name, whilſt the *iron-pyritæ* lay neglected, under the ſimple denomination of *pyrites*, or *ſtone-pyrites*, or *ſulphur-pyrites*, without any diſtinct appellation that ſhould denote the eſſence of it. At Friberg all ſuch are *iron pyritæ* as hold little or no copper.

That kind called *gold pyrites*, when accurately examined, as I have done all of them, proves either a highly coppery ſort, or the common *pyrites*, ſhewing externally of a beautiful gold-colour; theſe are particularly procured from Hungary, and have groundleſly raiſed extraordinary expectations. Tho' when any gold or ſilver is procured from *pyrites*, it may happen either from the ſpangles or threads of theſe metals, or from a genuine ſilver-ore being unobſervedly intermixed with the ſample under proof. Again, Men have been apt to be impoſed upon by the gold colour caſt off the ſample, whence the ancients called it *pyrites aurei coloris.* After all, the gold generally procurable by ſuch proofs is very inconſiderable, nay, what is to be met with in almoſt all mineral glebes, and in moſt, if not all ſilver, for procuring which no *pyrites* was ever particularly employed.

Much the ſame we may ſay of what is called *ſilver-pyrites*; the ſame cautions are neceſſary to prevent being deceived by the colour; in regard the *miſspickel* or *arſenic-pyrites*, that is, the white *pyrites*, by the ancients called *pyrites argentei coloris*, comes properly under that diſtinction, tho' uſually holding the leaſt ſilver, in compariſon of the yellowiſh and yellow: and tho' almoſt all *pyrites* hold ſome ſilver, yet it may be queried, whether it does ſo as a *pyrites*, without the intermixture of any other foreign vein. The mine-

ſecre-

secretary, Mr. Lichtwer, a person extremely well skilled in the business of minerals, shewed me sometime ago at Dresden a steely-close *pyrites-die* from Norway, from which there issued a pretty large thread of native silver: But this silver we must not consider as growing out of the body of the *pyrites*, but as something existing previous to, and encompassed by the *pyrites*, and which probably might have had its root or origin in a *quartz* or *spad*, as such a body actually adhered to it, and in such, native silver often lodges; having myself had from Norway a *quartzy* or flinty sample, closely intermixed with foils of silver, under the title of a *silver-pyrites*, tho' nothing of a *pyrites* was observable thereon.

From the other contents of the *pyrites* have arisen the appellations of *sulphur*, *vitriol*, *arsenic* and *sandarach pyrites*, and accordingly *pyritæ* have in some measure been sorted; in particular, sulphur and vitriol *pyrites* is a distinction without a foundation; seeing all *pyritæ*, containing sulphur, yield vitriol too; and all yielding vitriol, must needs have held sulphur: but it is proper to observe, that they must be first worked for their sulphur, then for their vitriol; and that *pyrites* once worked for vitriol, irretrievably loses its sulphur. So that this division of *pyrites* has only served to introduce error and misconception into the subject; as if these were quite distinct species of *pyrites*, and that some *pyrites* held vitriol formally, and in their native composition, in manner as most of them do sulphur. Tho' this is not to be taken strictly neither, as there are some attending circumstances to justify such a division, for the sake of illustration, tho' not of necessity: for instance, at Geyer in Meisnia there are chiefly two sorts of *pyrites*; the one of *Catherin-mine* at Johan-Georgen-Stadt; the other, of the *pyrites groove* of

Geyer itſelf: from both which ſulphur may be driven or procured; yet it is actually worked from the firſt ſort only; as the other, on account of its greater impurity, and conſequently large *heap-work*, and the tediouſneſs of working it, would not compenſate the trouble. On the contrary, there is vitriol procured from both ſorts: from the firſt, as the ſulphur and vitriol are almoſt at once worked for, or the advantages of working the ſulphur exceed the vitriol expences: from the ſecond ſort, as the expences of deſulphuration, wherein the proper furnaces, and veſſels, and attendance come high, are ſuperſeded, and the ore only prepared by a courſe of common *roaſting*. Now as that ſort from the *pyrites-groove*, on account of its foreign admixture, which is chiefly an iron-ſtone, is not worked for ſulphur, it may with ſome propriety be called a vitriol, and not a ſulphur *pyrites*, and may in ſome meaſure be oppoſed to the other: might not therefore the perſons, who firſt applied theſe names, have a regard to the ſpontaneous vitrioliſation of that ſort, and imagine them to have vitriol only, and no ſulphur? Now, from my own ſmall experience in thoſe matters, I look upon all *pyritæ* containing ſulphur, ſpontaneouſly to reſolve to a vitriol, tho' many ſlowly and with difficulty; the feweſt, with diſpatch and eaſe. Yet it might be allowed, to call thoſe that inſtantaneouſly vitrioliſe in their entire ſubſtance, without any refuſe, out of eminence *vitriol-pyrites*; as the Heſſian *iron-earth*, for inſtance, called alſo *Magneſia vitriolata*; and in general, the *pyrites* conſiſting of iron and ſulphur, without any other admixture, and of a round figure.

The diviſion into ſulphur and arſenic *pyritæ* is better grounded. Of the firſt ſort are all thoſe at the mines and ſmelting-huts, called ſimply *pyrites*, and employed for procuring that regulus, called *crude-ſtone*, ſulphur, &c. Again, all *copper-*

pyrites

pyrites and copper-ores, which tho' with us not work'd for, yet contain ſulphur. Tho' *arſenic-pyrites*, in its metallic contents, eſpecially iron, coincides with the other, yet in its volatile part it differs greatly. And tho' ſulphur and arſenic are often found together in *pyrites*, yet there are ſome without any arſenic at all; and again, not a few that contain no ſulphur, but only a pure arſenic. Further, tho' ſulphur and arſenic readily unite, yet are they never produced the one from the other. So that this diviſion, in preference to the others, particularly the foregoing, may be permitted as taken not ſo much from the different matters for which this ſort is worked, as from their different principles, and ſeems to have ſome foundation in nature. At Friberg tho' we uſe not the term *arſenic-pyrites*, yet we denote the ſame thing by *miſspickel* or *white-pyrites*. 'Tis here to be obſerved, that the black *arſenic-pyrites* or *fly-ſtone*, is not properly of this claſs, as being entirely fugitive, without leaving any fixed earth behind, and conſequently having one part only of the eſſence, and not the other fixed, metallic principle of a *pyrites*.

The appellation *ſandarach-pyrites*, has introduced numerous miſtakes: ſandarach is only a ſulphurated arſenic, or an arſenic tinged yellow with ſulphur, not having its own peculiar *pyrites*, contradiſtinguiſhed from the *arſenic-pyrites*, as one might be led to imagine: ſeeing it conſiſts of the very ſame parts peculiar to the *pyrites* itſelf; only that theſe are ſeldom lodged together in a due proportion, to fit them to be worked for ſandarach, without making ſome additions. In moſt *ſulphur-pyrites* there is at laſt procured a ſmall quantity of ſandarach (as moſt of them hold ſome arſenic) and but a little; and that either in the courſe of purifying the crude ſulphur, as is obſervable from the beautiful tranſparent, ruby-red ſublimate, and

orange-coloured powder, or from the residue or *sulphur-slags*, as they are called, with or without further treatment; or also in the roasting-huts, which generally appear done over with a red sort of glazing. Some *pyritæ* yield more of it, but still in the proportion to their sulphur and arsenic. Tho' to speak with propriety, it would be a difficult matter to find a *pyrites*, so mixed by nature, as without large additions to yield much sandarach, and not either mostly a sulphur, or a pure sooty arsenic; for, to compose a sandarach, the arsenic must predominate or exceed the sulphur by about 3 or 4 parts; and a *pyrites* of such a mixtion is very rare, and what I never myself observed; but rather, that where the *pyrites* greatly partakes of arsenic, the sulphur is deficient; and where, on the contrary, the sulphur is in a sufficient, not to say, a large quantity, there the arsenic is not so. The *misspickel*, or *white pyrites*, is therefore for the most part purposely mixed, either with sulphur-slags or with *sulphur pyrites*, as shall be shewn hereafter. 'Tis true, the *white-pyrites* might be, nay, by some is really called a *sandarach-pyrites*, and 'tis possible there may be *pyritæ* having such a proportion of sulphur and arsenic, as to yield sandarach without using any additions.

But the usual way of procuring a sandarach is to employ two sorts of *pyrites*, the white and the yellow, or to use, as additions, *sulphur-slags*; whence it appears, that sandarach is not a constituent principle of *pyrites*, but that it consists of two parts thereof, namely, arsenic and some sulphur, really, but dispersedly, existing in the *pyrites*, and run together in the course of the process for sandarach.

Smelters have likewise their *stone-pyrites*; to understand which, it is to be premised, that *stone* at the huts denotes that crude, semi-metallic body,

or

or that regulus, concentrated by ſmelting the coarſer ſorts of ores, and denominated either from the operation of *crude ſmelting*, or from the lead and copper, as the one or the other of theſe happens to predominate. In the operation called *crude-working*, the ſmall or poor, quartzy, rocky, mock-leady ores are, without roaſting, ſcorified, drained and concentrated, by means of the *pyrites* naturally adhering to the *mixt-work* or ore, or of what is purpoſely added, into a narrower or ſmaller compaſs or body, from their otherwiſe unſeparable and barren minerals; which body reſembles a ſtone rather than a metal. The *pyrites* here employed is commonly *ſulphur-pyrites*, in particular the coppery, nay, copper ore itſelf, if to be had. There is nothing extraordinary in this ſtone, only the name *pyrites* has been given to it by cuſtom.

If from the internal we proceed to the external conſideration of the *pyrites*, we ſhall find them of various figures and colours; as round, angular, oblong, flakey, &c. and white, yellow, &c.

The figures of *pyrites* being extremely various, the following are the principal;

I. *Pyrites idiomorphos*; which is, 1. ſpherical, or hemiſpherical; in this laſt form it is generally found radiated and lamellated; oval, cluſtered, criſtated. 2. Angular, conſiſting of four or ſix ſides; and this laſt cubical or teſſulated, oblong, rhomboidal, cellular, or honey-combed; of eight, ten, twelve, fourteen ſides, priſmatical, trapezian or irregular. 3. Bracteated or tabellated. 4. Fiſtular or piped.

II. *Pyrites ſymmorphos*. 1. Lithoxiloidical, as if fibrous, or pyritified wood. 2. Conchitical. 3. Cochlitical. 4. Cylindrical or Belemnitical. 5. Turbinitical, or Pyramidal. 6. Conical. 7. Aſtroitical.

Theſe various figures of *pyrites* are reducible to round and angular; unleſs we except the foliated,

and thoſe that conſiſt of parallel threads or fibres; the former appearing as ſo many accumulated leaves; tho' not ſeparable into tables or plates, like ſpad or Muſcovy-glaſs; the latter, as ſo many fibres in a muſcle, or piece of wood, tho' not actually to be parted into ſuch, as having received that appearance only from the piece of wood that happened to lie near them. Nay, the ſpherical themſelves conſiſt of pure radii or cones, whoſe ends jutt out beyond the external ſpherical ſurface, and there exhibit all manner of eminences, as may be ſeen by the ſmootheſt ſort, without a magnifying glaſs; ſuch are the Heſſian, and thoſe of Toplitz and Altſattel. But the half-round and the kidney formed, as thoſe at Friberg called *cobald*, conſiſt not of radii running from a center to a circumference, but of ſhells or coats, that lie upon each other; or whoſe radii run parallel, and to different points, conſequently forming no genuine ſphere. Of the angular, the four ſided is the rarer ſort; ſtill rarer is the pyramidal four-ſided; where a narrow ſide ſerving as a baſe, the other three equal ſides run to a point. A ſix-ſided *pyrites*, on the contrary, is more, nay, moſt common of all; with angles often ſo accurately ſquared, as if done by rule. Such I have had in particular from the Bannat of Temeſwaer and from Pretſchendorff; tho' not all ſo exactly ſquare, but that there were ſome rhomboidal, ſome quite irregular, with here and there ſides depreſſed, angles often broken off.

In general, we are to obſerve of the cubical (the ſeveral ſorts of which hitherto mentioned often lie together, as at Pretſchendorff) that they chuſe beds, where there are none of eight or more ſides. The ſix-ſided cellular or honey-combed ſort is remarkable in this, that the cells are ſo adaptedly filled with pieces of *Glitter*, as to ſhew like a ſet

of

of loose teeth, accurately fitting the sides, as if set with the greatest care.

The round *pyrites*, as was before observed, is either spherical or hemi-spherical The spherical, or whole round, have in the middle a point, from which shoot radii to the circumference, where these radii always project, either in smooth bodies, or in sharp points, often undistinguishable; and again, often striking the eye. The hemi-spherical, which are those arched, or bulging on one side only, are partly radiated, partly coated; both commonly consisting of an impure, namely, an arsenical sulphur, and being also somewhat coppery; whereas the whole-round are generally without either arsenic or copper, and therefore yield the purest sulphur and iron-vitriol. Besides these there is also a broadish, oval, round sort, usually called *pyrites-kidnies*; also a *botrytes*, or clustered sort, consisting, as it were, of pure, small globules (whither also are referable the cristated sort) and such configurations we often meet with in the *blood-stone*, or *glass-bead*: the cylindrical sort are cast in the shell of that sea-fish, from which the *belemnites* takes its figure, The cone-round, the *cochlites*, &c. have some sea-shells, in which nature has lodged and formed them, for the ground of their figure.

Scheuchzer has observed many of these round *pyrites* in Switzerland, washed down by rains and water-floods from the heights of the Alps, and supposed to be *lapides fulminares*, thunder-stones; not smooth, but unequal and rough; of a rusty cast, appearing radiated upon breaking, and glittering of the colour of gold and silver*. But he should have told us whether it was on account of their contents, or their colour, that he calls them coppery (*pyritas æreos*) as I have not hitherto observed

* Iter. Alpin. I. p. 2.

served a spherical *pyrites* that was coppery. In the island Staritzo, a like sort, of the size of oranges and lemons†, is found.

To illustrate the figures of the *pyrites*, in varying which nature takes a peculiar pleasure, it may be proper to consider those of other ores. Gold-ore, as such, is a rare thing, consequently it is difficult to ascertain any peculiar figure of it; the gold that is found in certain sands, clays, and other earths, in flints and stones, being rather in a native than ore state, as in spangles, foils, and grains. Silver-ores, as the *glassy* and *red-goldish* sort, have their peculiar figures; though the latter more than the former, frequently exhibiting ten or twelve sides, but they are oftenest found prismatical, like long angular staves or bars, yet of unequal sides, and like mountain-crystal, terminating in four or five unequal-shaped ends. 'Tis remarkable of *glassy ore*, that it is generally found of a cubical form, and regular enough; a circumstance never to be affirmed either of *red-goldish*, or any other ore, if you except *lead-glitter* or *galena*, and a kind of Swedish iron-stone of the nature of *glitter*. The white goldish ore may be deemed a copper, rather than a silver ore; and so indeed may the other two, from their yielding large quantities of copper. Iron-ore, or, as it is called, *iron-stone* (to distinguish it from *iron-pyrites*) generally consists in shoads or fragments, in *squats* or flat veins, exhibiting no peculiar figure, if we except that called the *glass-head*, or *blood-stone*, distinguishable partly by its spherical, partly by its hemispherical figure, and its brown-red, or russet hue, and thence denominated *botrites* blood-stone. Now as no other metal besides iron, is, in its ore-state, of a round figure, except that of *iron-pyrites*,

† Straussi itinerarium, p. 97. Confer. G. Agricol. in fol. p. 658.

tes, this circumstance cannot be deemed entirely accidental, but as what deserves our closest attention. Lead-ore, especially the sort called *glitter*, (*galena*) is always six-sided, partly cubical, partly oblong, and never observed of any other figure. That peculiarly rare lead-ore, which being commonly whitish, greyish, and greenish, holds no silver, not unknown at Tschopau, nor formerly here at the Tscherper, is always prismatical, and oftentimes flaky, like a *spad*. Tin-ore principally manifests itself in tin-stone, also in some granates. The former are mostly regular bodies enough, from ten to twelve sides; the latter are never regular, but with unequal angles and sides; some of them are pretty flat on their surface, and with angles only cut a little, or often quite away, and this either quite flat, or soon running into sharp points. Quicksilver-ore, which is principally cinnabar, has, besides its uncommon red colour, no native, peculiar figure; though quicksilver be in itself, by means of art, transformable into a thousand shapes: the reason may be, our not being always able to distinguish it in ores, or to strip it of its mask; to me it seems very probable to lie concealed in arsenic, and the like volatile, metallic bodies. Antimony-ore greatly resembles cinnabar, like it consisting of *spicula* or needles; with this difference, that in the latter the *spicula* always run parallel, but in the former they often appear like radii converging to a centre. Hither also are referable, with respect to their configuration, the beautifully red, steely-close *cobald-bloom*; the red antimony-ore; the iron-coloured, radiated *wolfram* of Altenberg in Misnia; also another russet sort from the same place, which is highly arsenical, and lastly, several bismuth-ores; seeing such distinctly manifest a radiated texture.

Precious

Precious ſtones may, with reſpect to their various figures, be ſuppoſed to approach ſomewhat nearer to the *pyrites*. The mountain-cryſtal, that is, the diamond white tranſparent ſort, as ſurpriſing as it is common in our mines, aſſumes all manner of figures; tho' the more common be either the cubical, or the priſmatical figure; this laſt running to a point with five unequal ſides and angles. Topazes, hyacinths, emeralds, ſapphires, and the like variegated ſtones, generally affect a cubical form: Tho' indeed the granate uſually is ſeen to have twelve and fourteen ſides (a thing not common for the other precious ſtones) and never to be priſmatical. 'Tis however to be added, that the granate (whether all I know not) is ſomething more than a ſtone ſlightly tinged; it is rather richly ſaturated with ſome metal, particularly tin, whether with gold is not ſo evident; ſo that it may juſtly claim rank amongſt genuine tin-ores. Of the priſmatical figure, we find at Stolpen in Miſnia a hard iron-coloured, black-grey marble, called *Baſaltes* (*a*) touch-ſtone; of ſeven, ſix, five, and ſometimes only four ſides, and of ſuch length and thickneſs as to be ſet up on end in the corners of ſtreets and near houſes. Of the like figure are the ſtones near the draining-hut of Grunenthal, in the road from Brandau to Gerkau. Of a triangular figure are the *quartz*, or flint of Anholt, an Iſland near Jutland; of which the learned in Denmark make mention, but which I never ſaw, any more than other ſtones of that figure (*b*). Laſtly, with regard

(*a*) Baſaltes derives either from Βασανίζω, I explore or try; or from Biſaltia, a country of Macedonia; and then 'tis the ſame as Biſaltes. Geſner, p. 21.

(*b*) Inſula hæc, inquit Olaus Borrichius, in ſinu Codano infinitos habet ſilices nigros, albos, varios, in ſabulo hinc inde ſepultos, at ſex tranſverſos digitos in longitudinem protenſos, latos digitum unum, omnes triquetros, ac ſi manu artificis fuiſſent

gard to copper-ores, I have, from manifold experience and observation, made this remark, that such *pyritæ* as yield no copper, are always round; those that contain only a little, of eight sides at least, and those that are richly stored with copper, commonly exhibiting ten, twelve, and more sides.

In a word, so far as my experience in ores and stones reaches, no one sort exhibits a greater variety of figures than the *pyrites*: and whatever figure nature gives any particular species of bodies, such it continues to have unchanged, nature seldom or ever swerving from the rule she has once laid down to herself, in any particular species. For instance, a *copper-pyrites* is never round, a pure *iron-pyrites* never angular, least of all polygonal; a *glass-bead* never like a *glitter*; a tin-stone never regular, &c. The reasons for which must be necessary, not accidental, and well deserving our careful attention and observation; for the structure and configuration of minerals may be considered as so many peculiar marks and *criteria*, from whence a better judgment may be formed of their nature, and consequently a more distinct description and history of them be attainable, at least as to their external appearances.

That division and distinction of *pyritæ* taken from their colour is a capital one; then I reduce them to three sorts, viz. white, yellowish, and yellow.

In considering the colours of mineral bodies in general, we are to observe that ores are metal impregnated with sulphur, or arsenic, or both: and this is sufficient to constitute the form or essence of an ore,

fuissent accuminati; & lateribus plerumque in illam faciem excavatis, ut Josuæ servire potuerint cultris faxeis filiorum Israel circumcisionem imperanti. Act. Hafniens. T. IV. p. 177.

ore, whatever other accompanying parts there may be in it. Sulphur is observed to reduce the white metals, and the semimetals, as silver, lead, regulus of antimony, to black, or black-grey bodies; namely, to a *glassy ore*, a *lead-glitter* and an antimony; with mercury alone changing to a beautiful red. The red metals, as iron and copper, it turns to a yellowish and yellow mass, which is our *pyrites*. Arsenic leaves white what naturally is so, and blanches or whitens what is not so. Tin it exhibits in its native white character, as appears from the tin-stone. Iron it brightens, as we observe in *Misspickel*, whose native earth is an iron. Copper, tho' naturally red, it thoroughly tinges with its own livery, as sufficiently appears from highly arsenical copper-ores. Silver it changes red, a remarkable instance of which we have in the *red-goldish* ores. For producing the yellow, brown and black casts in some tin-stones, some sulphur must accompany the arsenic, to account for an appearance so opposite to that of tin and arsenic. To avoid prolixity, I shall only hint, that arsenic and silver, sulphur and quicksilver, also sulphur and arsenic, do together exhibit colours extraordinary red. In *lead-glitter*, *glassy ore*, antimony, and *red-goldish* ore, the proximate cause of their colours lies in none of the parts whereof these bodies consist, but is first produced by an intimate action and reaction of these parts among themselves. In the others, and in many genuine ores, we observe the parts introduced bringing along with them their proper colour; particularly in the *pyrites*, where the sulphur loses not its yellow character; and the *iron-pyrites* turning only a little pale from the greyness of the iron; in *copper-pyrites*, on the contrary, the colour being heightened, from the common experiment of a red always heightening a yellow: arsenic is the manifest

nifest cause of the whiteness of the *misspickel*, or *arsenic-pyrites*; also of certain copper-ores, in which it exceeds the sulphur in quantity.

The three above mentioned capital colours of the *pyrites* are to be taken in a comparative, not a separate view: for, the *sulphur-pyrites* being viewed apart, shews white or grey; but placed near the *misspickel*, its yellow cast shews to greater advantage: in like manner the yellow ceases to be distinguishable, unless compared with the yellowish. The reason is, that these are three not very opposite colours, but easily running into each other, without destroying, tho' lowering or heightening, one the other: again, they stand in such a degree of mutual affinity, that many others different cannot be placed between them. These colours are to be understood as entirely penetrating into the substance and body of the *pyrites*; consequently they are not owing to the adjoining mineral, which indeed often strikes the eye in such a manner, that the *pyrites*, especially if lying interspersed therein, cannot well exhibit its natural colour; some caution also is necessary to prevent being deceived by the variegated, the red and green, the gold-yellow, the blue, &c. colours, which sometimes settle upon, without penetrating into the fibres or strings of the veins, and are usually called *copper-blooms*: to which must be added, that *pyritæ* being long exposed in the weather, change their external colour; whence it is possible to be misled by that powdery coloured substance, which is either ochre or verdigrease, arising in part from the destruction of the *pyrites*, and lying externally upon it, without making a part of its essence or composition.

This division taken from the colour will, upon trial, be found not only easy and distinct, but comprehensive of all the variety of the *pyritæ*. There

may,

may, 'tis true, be samples, not perfectly coming up to any of the abovementioned three colours; one yellow may happen to be higher than another, nay, needs must, as not agreeing in their contents, namely copper, to which the yellowness is mostly owing. The same holds of the yellowish, wherein often there is no arsenic at all, often very little, and often a great deal; now the arsenic lowering or bringing down the yellow, 'tis not possible to fix this colour to an indivisible point. The white alone is the most constant colour, as being owing to the arsenic; having observed that where it is lodged in the proportion, it bears in the *arsenic-pyrites*, not only the sulphur, which might somewhat alter the colour, must be entirely excluded, but the copper also. But these differences in colour are so very minute, as scarcely to be distinguishable; the three, that have been assigned, being to many difficult enough to discern with exactness.

The white *pyrites* is in essence or nature only the *poison-pyrites*, the *arsenic-pyrites*, the *misspickel* and *misspilt* of Friberg, and in external appearance not easily distinguishable from the *white-goldish* ore, the *smalt-cobald*, especially the latter, though darker, internally differing much among themselves. The genuine smalt-cobald agrees, 'tis true, in its volatile portion, namely, the arsenic, with the *arsenic-pyrites*, but in its fixed portion widely differs; seeing the true cobald smelts to a beautiful blue glass, which the *arsenic-pyrites*, on the score of its iron refuses. Cobalds are of two principal sorts. 1. That yielding the finest smalt, and appearing of the darkest grey, so as to be easily distinguishable among the *misspickels*. 2. A sort somewhat brighter, found also among the other, in lustre almost vying with the *arsenic-pyrites*, only a small matter darker than it; and yielding by far

not so beautiful a smalt or blue colour, as the other.

The *white goldish* ore, to which may also be refered the *white ore*, the *fallow ore*, and the *fallow-copper-ore*, in colour almost resembles the fine cobald, only smoother and thus more glistering, and with the greatest difficulty distinguishable from the *white-pyrites*. The *white* ore, which at the Halsebruke is usually called a rich copper ore, tho' far short of the *white-goldish* in goodness, is only a *fallow-ore*. Fallow-ore, which is a grey silvery copper ore, and *fallow copper-ore*, which is a copper-ore poorer in silver and richer in copper, are generally darker than the *white-goldish* ore, the *fallow copper-ore* being the darkest of all, whence it is easily known from the white *pyrites*, provided you can rightly distinguish it from the cobald, particularly the second sort, and from the white-goldish ore. There is a kind of antimony-ore from Schlaitz in the Voigtland, often so little radiated, as scarcely to be esteemed an ore of that kind, yet of so dark a grey, as never to be confounded with the white *pyrites*, the *white goldish*, the *cobald* and the fallow ore. To range the ores, hitherto mentioned, by the several degrees of their lighter and darker casts, and to begin with the lightest, they stand thus: First, the white *pyrites*, then the cobald of the second sort, next the fine *cobald*, then the *white-goldish* ore, the *white-ore*, the *fallow-ore*, and *fallow copper ore*. A person, not carefully comparing together and accurately examining these ores, may easily mistake, but a person of experience can directly upon sight distinguish, without the trouble of comparing them; and yet there are real differences, which may afford sufficient direction to a learner to make a distinction between such ores. At least the *arsenic-pyrites* does, in regard to the yellowish, or *sulphur-pyrites*, and

to the yellow, or *copper-pyrites*, rightly claim the title of *white-pyrites*; as compared with these it certainly shews white.

The yellowish and yellow *pyrites* are not near so hard to distinguish as the white. The former is a sort consisting of sulphur and iron, and having little or no arsenic or copper, and in different views, now called *sulphur-pyrites*, again *iron-pyrites*, and at Friberg simply *pyrites*. It manifests a middle colour between the true *copper-pyrites*, or the *pyrites-copper-ore* and the white *pyrites*; which colour can neither be called a white nor a yellow, but a yellowish, and discoverable upon comparing the white and the yellow therewith; as in regard to the white alone it must be deemed to be actually yellow, and in regard to the yellow alone, actually white; observing to learn to distinguish it from the dark vein-stone, the dark ores and minerals in mines, as mock-lead, glitter, &c. where its yellowness cannot strike the eye; and to guard against being imposed upon by the external, often gold-colour, which is only superficial; remember to break the sample, and judge of it as it shall then shew internally coloured.

The yellow *pyrites* may be easily distinguished; its peculiar characteristics are the copper and sulphur it holds: its yellow nearly coincides with a *siskin-green*, which might induce one to call it a green *pyrites* rather. But as in the colour, called siskin-green the yellow is the ground-colour, a little green only serving as a heightening; and as the second or middle sort of *pyrites* must have been called a yellow and not a yellowish, which the eye opposes; and then as the adjunct, green, might not have been so expressive, but apt to mislead to the mistaking it for a very different ore and mineral, done over with a copper-green or verdegrease; these are sufficient grounds for acquiescing

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in the abovementioned distinction of colours. At least the appellations, yellowish and yellow, are sufficiently expressive, to cause no mistake in the application of them. And provided we know how to distinguish the white *pyrites* from the abovementioned white or white grey ores, particularly the cobalds, which cause the greatest difficulty; there will be none at all, upon sight of the yellowish and yellow, or brass colours in ores, securely to pronounce such bodies real *pyrites*; as there are neither yellowish nor yellow ores, that are other than *pyrites*, consisting of sulphur, iron and copper.

In some authors we find the appellation *wild* applied to *pyrites*. *Wild*, is a term much used in mineralogy and applied to waters, ores, rock and stone. *Wild waters* are such, as weaken or spoil a brine or a mineral water. A *wild stone* or *rock*, what neither holds any ore or metal at all, or not the metal we look for. In like manner may the *pyrites* be called *wild*, when not answering our purpose, either for gold, silver or copper; as a gem may be properly called *wild*, which fails either in colour, purity or firmness;* is soft, pale, dirty, plumose and clouded.

To the *stone-pyrites*, procured from the operation of crude-smelting, and containing pure sulphur and iron, is usually opposed the *speise-pyrites*, an arsenical, semimetallic regulus, properly called *speise* and procured from arsenical *pyrites*.

The abovementioned divisions of the *pyrites*, taken from their nature, figure, colour, &c. have, as was said, their peculiar reasons, and may prove of use in natural history; not only for understanding the old writers, but the different methods of

* Rossler's Bergbau spiegel. p. 114, and 151. 7.

treating the *pyrites* itself; the ore-smelter having his *stone-pyrites*; the sulphur-master, his *sulphur-pyrites*; the vitriol-boiler, his *vitriol-pyrites*, &c. tho' they all mean one and the same thing: for the *sulphur-pyritæ* both yield a good *crude stone*, and are also proper for making vitriol.

The appellations, borrowed from the iron and copper, distinguish the metallic contents, and consequently the grand principles of their respective minerals; but may be apt to mislead, as implying iron not to be the ground-earth of all the *pyrites*; and excluding the other principles, viz. the sulphur and arsenic, which are quite lost in these appellations. The external figures do certainly denote something peculiar, which the colour may not: for from my own experience of various *pyritæ*, I may boldly affirm a spherical sort always to contain pure iron and sulphur without any the least copper or arsenic; yet hence it follows not, that the angular *pyritæ* always hold copper, seeing they partake of iron equally with the round; nor can we always distinguish whether a sample under examination be a part of a round or a half-round *pyrites*, which last holds copper considerably, or at least is not unmixed with arsenical parts. Consequently, so far as I have hitherto considered the matter, I find myself obliged to drop the figures and adhere to the colours, as affording the most proper division of the *pyrites*, and better denoting their internal properties, which the figures rarely do; the white *pyritæ* undoubtedly containing arsenic, the yellowish, sulphur, the yellow, copper. And a person much conversant in ores, will, upon sight, be capable to pronounce, whether the former consist of pure iron, or, of copper too, and the proportion of each; the business in this case resting on the various degrees of one and the same colour, not to be described by words, but learned by a repeat-

repeated inſpection and compariſon of ſamples. The following circumſtances however may help our obſervations thereon; the more the yellow inclines to a ſiſkin-green, the more dead and leſs gliſtering it is, and the cloſer more clear-grained and firm the ſample, richer the *pyrites* proves in copper.

It has been already remarked that the whiteneſs of the *pyrites* is a ſign of its arſenic, and I might add of its iron too, but that there is a ſingle, yet rare, inſtance ſtanding as an exception: at Chemnitz or Stolberg in Miſnia, there is a whitiſh *pyrites-copper-ore*, holding at the rate of £ 40 the quintal, plainly diſtinguiſhable from *miſspickel*, in its pale colour, compactneſs and firmneſs, tho' in a manner not to be deſcribed; however as its whiteneſs is owing to its arſenic, it ſtill remains a general propoſition, that arſenic imparts that colour; tho' it be difficult to diſtinguiſh the whiteneſs faſtened on the copper in this uncommon inſtance, from that on iron in the *miſspickel.*

CHAP. IV.

Of the Beds of the Pyrites.

THE yellowish or *sulphur pyrites* is met with in all manner of stone: 1. in *quartz* or flint it readily lodges; this very close, firm stone generally affording beds, and directing to ores, that when once discovered, the Miner imagines himself to be, if not in the actual possession, yet in the tolerably certain hope of meeting with an ore; it also forms the *selvages** of Veins, and encompasses the *pyrites* as so many shells or coats. The *pyrites* often adheres externally to *quartz*, as if run or melted upon it, or sticks like grains or buttons, or like sand strewed on it; as is particularly observable in the beautiful colours of the *copper-pyrites*.

2. In Marbles, called in the language of Miners, *horn-stone*, and resembling *quartz*; except that the former are generally white, seamy, veiny and flakey; the latter for the most part coloured, as brown, yellow, red, grey, black, &c. and moreover are not so remarkably veiny, but closer and consequently fitter to work. I have more especially observed the *pyrites* on red and yellow jasper, chalcedon, and the like, which are not unduly classed amongst marbles.

3. In

* A vein has its bed and cover of rock, both which are parted or discontinued on the sides of a vein, and these sides covered with quartz, or with a finer kind of mold; and this is what Miners call the *selvages*.

3. In *ſpad* which is directly oppoſite to *quartz*, being a flakey, crumbley, ſhivery, calcarious ſtone, more frequently entirely white, but ſometimes of a brown-red or ruſſet, as well as of other colours, and ſofter than *quartz*; ſo as to bear being ſhaved with a knife, nay often with the finger-nails; whereas *quartz* often approaches to a diamond in hardneſs; tho' *ſpad* be heavier than *quartz*, to a degree of giving a ſtrong ſuſpicion of its holding a metallic body, little or no metal hath hitherto been procured from it; this ſpecies of ſtone having conceived more of the mercurial, metallic earth than of the quartzy, glaſſy, firſt earth of Becher; now in and upon this *ſpad* the *pyrites* as readily fixes, as it is common in our mines. I have had ſeveral inſtances of *pyrites* in tinny vein-ſtone, where Muſcovy-glaſs, a ſpecies of *ſpad*, uſually *breaks*.

4. The *pyrites* lodges alſo in lime-ſtone, gypſum, alabaſter, &c. Not *vein-wiſe*, but rather *neſt-wiſe*, and *kidney-wiſe*, unleſs where other veins, carrying along with them *pyrites*, happen to traverſe; as appears from the calcarious *ſhoad* of the Schloſs-berg near Toplitz.

5. *Shiver* not only holds *copper-pyrites*, or *copper-pyrites-ore*, as being what is common to it, but alſo *iron-pyrites*; there having been ſent me a ſample in particular from the Shiver-quarry near Goſlar, where it forms a genuine flat-layer or ſquat.

6. *Pyites* lodges alſo in ſtone-coals, a thing not to be wondred at from their great affinity, as both have ſulphur in common, which abundantly appears from the ſtone-coal works at Peſterwitz near Dreſden.

7. In ſand-ſtone, of which thoſe brown-red, oahry, iron-ruſt neſts obſervable in ſtone-quarries are ſufficient evidence: and in particular at Burg-

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thanne in the territory of Anſpach we find a dark, ochre-brown ſtone, concreted of ſand, or a ſand-ſtone and *pyrites* particles of the ſize of hemp ſeed, ſome ſmaller, ſome bigger, of eight ſides.

8. Of *pyrites* in lime-ſtone we have inconteſtable evidence from the famous lime-ſtone quarry of Querfurt, from the Schloſsberg of Toplitz, and in particular from the Beyerberg in the territory of Anſpach, immediately beneath the under-turf earth.

9. In loams and clay pits *pyrites* is often met with; the Heſſian iron earth ſhews this: and the Pretzſchendorff *pyrites* lies towards the *day-ſquats* in a fatty, *talcky* vein-ſtone.

10. We find *pyrites* in a kind of marly ſtone, a fatty, clear ſort of ſtone-earth, commencing a ſtone, yet not ceaſing to be an earth; as may be ſeen at Toplitz, and from a large quarry at Cottitz in Bohemia. *Pyrites* lodges alſo in *gemſs*, a ſoft, flakey ſtone, lying between the inner, hard rock and the outer garden mould.

11. *Pyrites* we find in that rocky vein-ſtone ſtriking out to the *day*, called by miners *knauer*, and to be denominated a wild, barren, dead ſtone, from its not yielding any metal.

12. *Pyrites* uſually manifeſts itſelf in and near all the wrecks or remains of the Deluge, but oftener in the fragments of minerals than vegetables; and in what are called the muſſel, periwinkle and horn Works; as the country about the Wirtemberg Bath at Boll plainly ſhews in a vaſt variety of ſamples. And Dr. Balthaſar Erhard of Memmingen has furniſhed me with Samples of *cornua ammonis*, *pectinites*, *cochlites*, *conchites*, *belemnites*, *lapides judaici*, *&c.* either filled or over-laid with *pyrites*. And indeed it is found not only in and upon petrified pieces, but on ſuch as have remained unchanged, only become ſome-

ſomewhat calcarious, tho' ſtill retaining the nature of their proper kingdom. I have procured from M. Roſinus of Munden a piece of *pyrites*, that manifeſtly ſhewed it to have been wood, not only by its texture and growth, but actually having ſome of its original adhering to it; tho' a muſſel or other ſhell is by its nature better adapted for the conception of *ore-weatherings* or damps, even in its unchanged form: and Liſter (*a*) mentions a *pyrites ligneus* in Ireland, ſuppoſed to have been aſh-wood, turned to a load-ſtone of the firmneſs of marble.

So that there is ſcarce any ore or vein without the *pyrites* conſtituting either a principal, or at leaſt an incidental, if not the whole part of the compoſition. Gold-ores we have properly none in Miſnia: and as to the foreign, namely the Hungarian, I can form to myſelf no regular conception thereof: I have been ſhewn a ſample from Schemnitz, yielding ſome ſilver, but upon a narrower inſpection there appeared a variety of veins; as I have often obſerved *glaſſy* ore, *red goldiſh* ore, *glitter*, *mocklead*, *copper pyrites*, *iron-pyrites*, *yellows*, *blacks*, *gooſe-dung* ore, *cinnabar* ore, all within the compaſs of a ſmall ſtone, weighing only a few loths (*b*) or ſome of theſe ſorts lying one on the other, and ſo intermixed as often to be ſcarce diſtinguiſhed by the eye tho' aſſiſted with glaſſes. This I have obſerved that the *copper-pyritæ* of Hungary anſwer beſt. But if I take to aſſay for the perfect metals a pure iron, and thus an entire clean *pyrites* (for the copper yield does not properly belong to the eſſence of the *pyrites*) as I have had ſuch from Schemnitz I have found the reſult to be nothing at all. But under the appellation gold-

ore

(*a*) De Fontib. Med. Angliæ. p. 23.
(*b*) A loth is half an ounce.

ore we must not include a corporal, native gold, which particularly in Transilvania we surprisingly observe sprouting out of, or wedged into a clear *quartz*, without the least distinguishable trace of an ore or vein lying near it, as being already a native metal; whereas an ore, on the contrary, holds the metal in a quite different form, being blended with various sulphureous, arsenical and other matters. There is a certain kind of *quartz* or flint exhibiting on its fissures a rusty sort of iron, which might be taken for a gold-ore: but 'tis to be doubted, whether this rusty matter will, after parting the gold-spangles from it, yield any metallic contents: and 'tis known, that a native metal may lie in *mixt-work* in so light and tender a form, or by the operation of stamping be so reduced to a dust, as that the noble metal cannot be *sludged**, but be carried away by the stream, and lodge among this ferrugineous matter, which is taken for proof. And as to the eduction of gold out of *mixt-work* of more than one sort of ore, inseparably run into each other; the question will be, whether the eduction depends on one alone, or two or more of these ores; or whether it holds not here, as with many minerals, nay pure earths, which of themselves containing nothing of the noble metals, yet mixed with other ores, which also separately give nothing or contribute but a certain proportion, prove *yieldy*, as I have with certainty experienced of chalk in particular, and other sorts of earth. In such processes I know not whether I should call the produce a *maturation* or a *transmutation*. This at least

* In the operation of washing ores mixed with earthy rocky and other light matters, in order to the separation of these last; the heavier metallic parts subsiding to the bottom are called *sludge*; in High-Duth, *schlich*, whence our English, *sludge*, seems to have been derived.

least holds true, that between eduction and production there is a great deal of difference.

But in order to determine, whether *pyrites* lodge with gold-ore, we must first ascertain the proper sorts of real gold-ore. For *glassy* ore, *copper* ore, and the like, which in Hungary above other ores, (for instance, above those of our mines) are goldish, are properly silver and copper ores, their ground-substance consisting of silver and copper, and their gold being only incidental, seeing without disadvantage to their principal constituent parts, the gold in these may be little or none at all. And should such be accounted gold-ores; 'tis well known that not only *iron-pyritæ break* on all hands of such veins, and that copper-ores, which are themselves *pyrites*, principally affect and exhibit gold, but also that near and upon white *pyritæ* we often find native gold.

Pyrites most readily lodges near silver ores, as the *glassy*, the red and white goldish sorts, which may properly be called silver-ores; yet near these rich veins lodging as a copper rather than as an iron *pyrites*; and where it proves the last, as an arsenical or cobaldish, rather than an erratick *sulphur-pyrites*, as I have observed from numerous samples. What is remarkable, I never observed a native silver, whatever pains I took to enquire about it, either on the white, the yellowish or yellow *pyrites*. Two single samples only I have been shewn, tho' properly not referable thither; one, a *pyrites-die* or marcasite, traversed by a silver wire or rather a silver wire encompassed with a *pyrites*; the other, a piece of a *pyrites* partaking of a silver-ore, of the *glassy* sort, from our Obergeburge. The silver neither lies on, nor grows out of the first, but must needs have existed there originally, and afterwards by means of the subterraneous *weather* or damps happened to be encompassed by the *pyrites*. The

second

second was far from being a pure *pyrites* being plainly enough mixed with the above silver-ore; which, and not the peculiar substance of the *pyrites*, was the ground, whence as from a root, the native silver, upon a narrower inspection, appeared to proceed. And how can we expect to have silver growing from *pyrites*, when we know *pyrites*, as such, to hold little silver, its silver generally amounting only to ¼. ½, 1, at most 2 drams the quintal, and consequently no silver growing out of it: And hence may be deduced these useful truths; 1. that *pyrites*, especially the pure sulphur and iron *pyrites* cannot be the mother, or producing matter of the nobler metals, as many might imagine from its universal spread; for instance, here in Misnia, it always accompanies silver-ores, and appears necessary to their generation and encrease. 2. That in judging of veins and ore, we are not to suppose that matters accompanying, or even intangled with each other, proceed the one from the other; but we are rather to look on their substances, either produced at the same time, or meeting together afterwards. And if *pyritæ* have no *generative*, they can not be endued with a *conceptive* power for silver. *Grown* or native silver, so far as I know, and have had instances, is found on *quartz*, *spad*, *shiver*, *kneiss**, *ochre*, *jasper*, and all manner of *horne-stone*, on *gemss* and *glimmer*, on common quarry stone and *knawer*. Among ores, chiefly on *smalt-cobald* (to find it on *red-goldish*, *glassy*, and *white-goldish* ore is not uncommon) a peculiar instance of which we have in the *smalt-cobald* of Lacray in Lorrain. Fibres of silver are also sometimes found in and upon iron-stone; but on *pyrites*, either white, yellowish, or yellow, as such, never, or at least it has not hitherto been heard off.

There

* A black, fatty sort of vein-stone or rock.

There is no instance of it on lead or tin ores. And the *foil-silver*, manifestly sprinkled on the glimmery granate-ore from Norway, lies rather on the fissures or fibres traversing this vein-stone than on the granate.

The same may be affirmed of native gold, and the like attention is to be used in judging of the gold-samples. Yet so far does gold differ from silver, that it is usually to be met with on white *pyrites*; of which it may at least be said, that it is peculiarly fitted for the conception of gold. Again, native silver is chiefly lodged with arsenical ores, excepting white arsenical pyrites; native gold in cinnabar and quicksilver ores.

In the coarse veins, as they are called at Friberg, where we chiefly look for lead and copper ores, *pyrites* more readily lodges than in silver ores. Nay in these last pyrites is either entirely absent, or so sparingly present, as that in many places, as at Schenceberg, Johan-Georgen Stadt, &c. the ores can hardly be worked without it, so indispensably necessary an instrument is the *pyrites* in the smelting huts.

The *pyrites* proves a sure guide to *lead* and *copper* ores, which with us are not easily separable, seeing they generally lie so mixed together, or so near each other, in one and the same vein, that it appears almost impossible for the one to be without the other: and indeed it is no easy matter to find a vein in the earth, in what direction, and to what depth soever it runs, unaccompanied with *pyrites*. And of the coarser veins, especially genuine head-veins, it may moreover be said, as those of Hartz can verify, that *pyrites* is often, in company with *misspickel* and mocklead, to be met with, as far as levels and shafts have hitherto reached. And tho' as a pure *iron-pyrites*, it often loses itself, yet it does not as a *copper*, nay it often is present in both forms, intermixed with *galena*, and frequently wound

wound up in, or joined close to it. The peculiar silver-veins rich in *glassy*, red and white *goldish* ores remarkably differ from the abovementioned coarse sort, as the *pyrites* generally keeps at a distance from these, nay is seldom found in the *selvages*. But I would not be here understood of veins, where some of the above noble ores are either interspersed in fissures, or *weathered* on *druse**, or lay sprinkled on the firm *mixt-work*; most of which will be found to consist of *galena*, copper-ore, *pyrites*, mock-lead, *misspickel*. The same remarks will hold good of other coarse veins.

I have observed the *pyrites-kidneys*, as they are called, to be of different sizes, some equal to musket-balls, granado's, and others even as large as cannon-balls, tho' oblong, and of a flatted round, rather than quite spherical; and generally give no tokens of being mixed with copper, whether examined by the eye or tried by the fire, yet there are some as those of Frankenberg of a flat-round, like the shell of a tortoise, that at times internally manifest some copper-ore, mocklead and *misspickel*, which the external appearance of such close bodies would give no suspicion of. And tho' the *pyritæ* disappear in *glitter-stock works*, as those of Hartz; neverthelefs they are again found when the large stock or belly, formed here by the ore, and called *stock-work*, comes to contract again; as it doubtless must, tho' it runs, as is well known, to several small strings, difficult, if not impossible, to be traced.

From

* *Druse* in the *German* Mineralogy, denotes 1. Honey-combed ores, or such as are pierced with many holes, like honey-combs, by means of the subterraneous weather or damps. 2. The variegated crystals, filling up these holes again and called *metallic fluors*, or spars.

From the affinity in fundamental principles between *pyrites* and iron-ore or iron-stone, we may well suppose the former generally to lodge with the latter; as *pyrites* chiefly consists of iron, being only a sulphurated iron-stone; much as cinnabar is a sulphurated quicksilver, or antimony, a sulphurated arsenical* semimetal, called *regulus*: and indeed we find in iron-stone small cubes of *iron pyrites*, as in that of Orbis in Bohemia. And here 'tis peculiarly to be remarked, that the *pyrites* includes a traversing white limestone vein, which supplies the true *selvages*; circumstances I have also observed of the *pyrites* in the stone-coal of Peterwitz. We also find therein a *copper-pyrites*, or rather a coppery *pyrites* traversing it in veins as appears also from the same *pyrites* of Orbis. This the iron-smelters find to their cost, when not sufficiently separated from the iron-stone; the sulphur, tho' entirely forced out, leaves behind it in the iron an untoward quality: and by means of the copper, from which sulphur is with difficulty separated, adheres still more closely to the iron, and taints it (as it does all metals in their degree of malleability and metallicity) rendering it brittle and short. A coppery iron, indeed, does, when cold, manifest a sufficient degree of toughness; but when hot, it easily snaps, falls to pieces, and solders not again, and is least of all fit for making steel. That the *pyrites* lodges near that red sort of iron-stone, called *glass-head* by miners, and by druggists, *blood-stone*, cannot well be doubted of, tho' I never saw nor read of an instance of that sort.

Tin-

* Dr. Meuder in his Analysis of Antimony seems to allow of no arsenic in the regulus of antimony. Our author speaks according to the common opinion, viz. that the regulus of antimony is a mercury fixed by arsenical vapour.

Tin-ore, at firſt ſight, ſeems to have ſome, tho' a diſtant relation to *pyrites*, by its partaking of arſenic, whereby the tin or metal lodged therein is reduced to an ore ſtate; and in this reſpect, the white *pyrites* or the *miſspickel* is nearly allied to it. But to ſhew any ſulphur, which is the principal characteriſtic of the *pyrites*, in pure tin-ore is a very difficult matter. Notwithſtanding which, the *pyrites* does not forgoe its natural privilege of being univerſally preſent, as it every where joins itſelf to tin ore: and iron-ſtone reſembles it ſo very much, as ſcarcely to be diſtinguiſhed from it by the ſharpeſt eye; ſo that a ſeparation muſt be made by the magnet: and yet, what is remarkable, iron, which is ſo hard and ſtubborn, and alſo copper, incorporates with tin, which is ſo ſoft a metal; and thus may the *pyrites* in its metal-earth be conſidered, as eaſily combinable with tin; tho' by that means the tin be rendred ſomewhat hard, and in the language of the tin-workers, *thorney*, whence the Engliſh tin, which equally with its ore, is free from iron, is ſo univerſally eſteemed.

That *pyrites* lodges with antimony-ores appears from the antimonial ſilver-groove at Braunſdorff. In which moſt of the ore, together with the interſperſed *red-goldiſh* ore, and ſome *hair*, alſo ſome *foil* ſilver, conſiſts of an arſenical *pyrites*, with a little copper ore: and the entire vein, which in many places is above a fathom *mighty*, as miners ſpeak, or thick, is throughout ſo charged with antimony, that the whole of it may properly enough be called an antimony ore. And it may here be affirmed, that tho' iron, the firſt principle of the *pyrites*, may ſuffer tin, yet by no means will it the *regulus*, which is the principal part of the antimony.

The *pyrites* is alſo preſent with the ore of quickſilver, particularly cinnabar, as in the matter of their

their sulphur these have a great affinity with each other. And I have had a beautiful sample of cinnabar-ore from Transilvania, where the *pyrites*, being quite of a steely closeness, lay within it, like a kernel in a shell.

It may in general be said, that the *pyrites* is to be met with in as different forms and position as other ores are. These are, 1. *vein-wise*; when the ore stretches downwards, oftner sloping a little, seldom quite perpendicular; and still growing wider or larger like a vein towards the heart. 2. *Squat-wise*, or in a horizontal position; that is, if not always quite level, yet hanging much and dipping a little. 3. *Nest-wise* or *kidney-wise*; that is, as so many eggs or kernels in a kind of shell, thrown together at random; without any particular connection, either with other ores, the adjoining veins, or among themselves. 4. In *stream-works*; which we may consider as so many banks or beds, caused by the deluge; they are found sometimes so very large, as to be called *stock-work* or bellies; tho' by their extension, undoubtedly belonging to the class of *squats* or flat veins. 5. In shoads, which are broken pieces or fragments of rock and stone, lying directly beneath the under-turf earth, and at times, by rains and floods, left quite naked; and with great violence, the effect of the deluge, washed and tore away from the veins; at length they acquire the appellation, *stream-work*, when much ore and rock, thus *shoved* or pushed away, happens to lie together in a large compass. 6. And lastly, a circumstance not the least remarkable, is, that ores are found upon *sinter*, or drop-stone, in the sides and roofs of old mines, a proof of their temporary existence, and that they are not coeval with the world.

In all the above forms may the *pyrites* be found. For, 1. It breaks in genuine constant, ore-

veins; often entirely alone, as we have an uncommon instance at Pretzschendorff; but for the most part it accompanies other veins, as was above observed; scarce ever without mock-lead being included in the very heart of the *pyrites-dice*, as we also learn from the Pretzschendorff. The *pyritæ* setting or reaching as low as *levels* have hitherto been driven, or shafts sunk, often appear to contain copper, but soon after afford only a pure iron; thus proceeding on, till by reason of the waters, they can no longer be traced. Of this we have ocular demonstration from the Croner-mine at Friberg, and from the territory of the Tscherpe and Hohenbirk, and an undeniable proof from volcano's and subterraneous accensions; as their inflammable matter is probably, among other things, derived from the *pyrites*; which from such mountains being unexhaustible, must be distributed, not in a scanty and superficial, but in a very plentiful manner at unfathomable depths: and again, the *pyritæ* extend outwards quite to the under-turf earth, or almost to the *day*, tho' the other accompanying minerals in the extremities, or first beginnings, are wont to disappear or vanish: or, conversely, most ore-veins manifest themselves from without inwards first of all by the *pyrites*; assuring the miner, from unexceptionable experience, of his being either already upon, or not far off a capital vein.

2. The *pyrites* affect a squat or horizontal bed, as *shiver-mines* sufficiently shew; the *pyrites* always inclining to extend and stretch laterally, which is what we commonly call a *squat* or flat vein. Generally they are copper, very rarely iron *pyritæ*, that affect this sort of bed: and such *pyrites-squats* are commonly without any admixture of other veins, as *mock-lead*, *misspickel*, *glitter*, &c. which is the reason that the copper from Shiver-Mines

is

is finer, fitter for uſe, and more valuable than that from mixt vein-ſtone. Again, ſtone-coal pits give an ocular demonſtration to the ſame purpoſe; but here the *pyrites* is rather irony than coppery. *Pyrites* is alſo readily found along with lime-ſtone, as the abovementioned iron-ſtone of Orbis ſhews: and in lime-ſtone beds probably, as theſe commonly form *ſquats*; tho' I cannot affirm, I ever ſaw much *pyrites* there, as I have in *ſhiver* and ſtone-coal.

3. This mineral has been found to manifeſt itſelf *neſt-wiſe*, or *kidney-wiſe*, in proportion as the foſſils, that lie near us, have begun to be more carefully examined: and thus it appears not only in loams, lutes or clays, in marles, in marley lime-ſtone and in lime-ſtone, but with this difference alſo, that whereas in real ore-veins it is not unmixed with *mock-lead*, *miſspickel*, and conſequently arſenic and ſandarach; here on the contrary it is quite pure, with only its iron and ſulphur, ſeldom any copper.

4. In *ſhoads*, or broken fragments of veins, and conſequently,

5. In *ſtream-works*; as the *pyrites* may, equally with other *mixt-work*, be ſuppoſed to have been torn and ſhoved from their veins, and accumulated by ſtreams or floods. Nay, according to Roſſler *, Druſe, Wolfram, alſo granates, and iron-corns, nay, even quickſilver itſelf, is found in ſtream-works.

6. It deſerves peculiar attention, that in old mine-works, the *pyrites* is found grown anew on *ſinter*, of which in the following chapter; a circumſtance ſerving to convince every impartial enquirer, that the *pyrites* lying on *druſe* and fiſſures, are, with reſpect to their origin, the effect of a

* Berg-bauſpiegel, p. 12.

temporary growth, and by no means a primitive work of the creation.

7, and lastly. The *pyrites* is no ways uncommon in bodies of the other two kingdoms; such as by accident, particularly floods, have chanced to light upon proper beds, and there have petrified, or changed to earth; as the periwinkles, muscles, and other sea-shells, at Boll, in the territory of Wirtemberg, fully shew. Tho' the instances of vegetable bodies are not so very common, yet, at a considerable depth (not to mention now the piece of wood reduced to *pyrites*, spoken of above) we meet with beds, shoved, or laid one over the other, of a *pyritous* alum, resembling, both in external form, and texture, nothing more naturally than pieces of wood; nay, sometimes entire large trees.

I would not here be understood as insisting on the absolutely universal presence of the *pyrites*; for, were that the case, smelters, in some places, could be at no loss to work their poorer sort of ores: but my meaning is, that there is scarce any ore so common as the *pyrites*; no one sort of ore, stone, mineral, or earth, wherein it does not lodge; nor any mine, wherein it can well be a stranger; though here and there it is not found without some trouble and difficulty.

The reader is to be apprized, that, after the Friberg manner, mentioning *pyrites* simply, without any adjunct, I principally intend the yellowish, or, as it is there called, the *sulphur-pyrites*. The yellow, or *copper-pyrites*, or copper-ore, is generally found in the same beds as the yellowish; but never, so far as my experience reaches, in such round balls, or nuts; though often lying huddled together, like so many broken pieces or fragments. And should some copper slip in among the round *iron-pyrites*, yet it is never found in such quantity,

quantity, as may properly entitle it to be classed with the yellow *pyrites*, nor, consequently, with the copper ores. I never had an instance of the yellow *pyrites* in lime-stone, gypsum-stone, alabaster, &c. How the case stands with stone-coal, I know not. Sand-stone, so far as my experience goes, should have little of it: muscles, periwinkles, and the like shells, reduced to *pyrites*, never have a sufficient quantity of copper, to entitle them to rank with the yellow *pyrites*, or copper-ores. The white *pyrites* I never missed, but in shiver, 'till a specimen I once had, shewed it there interspersed in grains. Having long, and in vain, looked for it in lime-stone, a sample from Sweden shewed it also intermixed there: but in sand-stone, so far as my observations and enquiries have gone, I never had any instance of it.

The *pyrites* is found also in water, but neither as in its proper matrix, much less, as springing from water, as from its seed. The curious Dr. Daum, of Dresden, sent me, from the island Heiligland, in Holstein, a *pyrites*, under the title of *marcasita aurea marina*, which is sulphureous, arsenical, and also something coppery; and moreover, of a variety of figures. It is thrown on the shore by strong easterly winds, and driven back again into the sea, by westerly. It was, undoubtedly, lodged in earth, or rock, and broken loose by the waves. Dr. Major mentions some remarkable circumstances about it; as, that in the fire it will emit a kind of cinnabar, or rather, a sandarach, of the colour of cinnabar; also flowers, of an ultramarine colour; though this I never observed, nor heard of, in any other *pyrites*; nor can I imagine it should yield any such flowers. *Earth-blues*, of which kind are *ultramarine*, *chrysocolla*, *mountain-green*, and *Malachites*, are derived, 'tis true, from copper-ores, and thus from

pyrites; but not by means of fire, but of the *weather*, both that above and under the earth; as we may often see, in the greatest perfection, in copper-ore slags, or *scoriæ*, after having lain long exposed on heaps in the air. Further; such *pyrites* is found accompanied with Belemnites, so that the inhabitants called it *false gold*; tho' I leave it a matter undetermined, how far it deserves the title of a gold Marcasite (*a*). The abovementioned author has with it performed all the experiments of lightning, and found the metallic globules melted from it, to cause in the hand the very same burning that real lightning does, namely, a smarting, yet without any stains, or other hurt; also, in falling down, to set blotting-paper on fire.

From what has been said, it may be usefully observed, that a great deal of attention is requisite, in forming general conclusions, and axioms, even after a vast number of experiments have been made. It is extremely remarkable of the *copper pyrites ore*, that it is never to be met with in lime-stone, gypsum-stone, alabaster, and the like: consequently, that the nature of the stone and earth may serve, if not as a matrix, to contribute to, or lay the foundation for, the generation of ores, yet, at least, often to impede their production. Were there no instance of a copper ore in shiver, where, notwithstanding it is in great plenty (so very peculiarly fitted may the fatty, slimy shiver-earth be for the conception of copper ore) and in spreading *squats*, it could not fairly be thence concluded to be in none. So in regard also to lime-stone and sand-stone, wherein it is never found, we might easily imagine copper-ore never was, nor now is produced *vein-wise*, but all of it ori-

(*a*) Majoris memoriale anatomico-miscellaneum, obs. 3. §. 4. 17. seq

originally created; as all ſuch ſtones and earths, conſiſting of ſand, of calcarious and ſlimy matters, the reliques of the flood, becoming afterwards hardened, were without copper-ore. And thus, propoſitions abſolutely general, are not eaſily to be admitted into the ſcience of nature: as we cannot well conclude, that becauſe a thing has not been hitherto ſo obſerved, it neither is, nor can be ſo. That a thing exiſts, and in ſuch and ſuch circumſtances, we may aſſuredly affirm, but that it cannot be in any other than theſe, would be indiſcretion to aſſert. And with this I might juſtly charge myſelf, ſhould I, from copper-ore not being hitherto found in lime-ſtone, thence form a general concluſion. In the mine-hiſtory we have many very curious remarks, deduced from much and long experience: for inſtance, that ſuch and ſuch circumſtances, and the appearance of ſuch and ſuch minerals, give hopes of ſome ore or other; but it might tend to great miſtakes, to form unlimited, abſolute propoſitions from ſuch remarks: for, often, the ores preſumed, either appear not at all, or very different from what was expected. From the nature of the upper-garden, or under-turf mould, we attempt to form a judgement of the ſubjacent mould, of the preſence or abſence of any ore, and of this or that particular ſort of ore; as if the lower contents were neceſſarily derived from the upper: we are, therefore, carefully to avoid being too precipitate in forming axioms and concluſions. Our buſineſs, firſt of all, is to make obſervations, proper remarks, and collect inſtances together, without pretending to deduce any conſequences: for how ſuperficial often are even the moſt accurate remarks and obſervations! Our experience is chance-work; our ardent purſuit after riches ſo much engroſſes our thoughts, as to make that our only end in the

business of mining: and who is the person, that will give himself the trouble of carefully examining what even chance throws in his way, if such examination does not afford any prospect of gain, or arrest his attention by its beauty, or uncommon appearance? Lastly, who is the person diligent enough to set down, and register his observations? the omission of which, will ever render any part of natural history uncertain, and defective.

CHAP. V.

Of the Production and Generation of the Pyrites.

WITH respect to the origin of the *pyrites*, it is proposed to consider the three following particulars. 1. At what time. 2. From what principles. 3. In what manner it was produced.

As to the first, it is highly probable, that the *pyrites*, as it now lies in the bosom of the earth, did not all originally exist from the creation, but that most of them have been generated at different and successive periods; which generation will, in all likelihood, continue to the end of all things. It is also probable that minerals, in general, constituted no principal part of the first creation, as the common division into three kingdoms would seem to insinuate; but are to be considered rather as something incidental, produced occasionally, as the opportune concurrence of proper materials have served that purpose: not but that within the term of the Mosaic creation, both the ore-matrixes, as the firm rock, or stone, and the ores, and native metals began to be produced; and so far we may well affirm minerals to have been created: yet, to speak more

more precifely of the nature and original of the mineral kingdom, from reafon and experience, we ought not to afcribe to that period all the mineral veins and fibres, we either know or conjecture to exift in the earth; nor fhould we imagine, that the veins of ore were at the firft formed.

Doubtlefs, at the very beginning, actual ore has been generated in the deepeft and innermoft bowels of the earth, or has there firft taken its rife: feeing the fea, that univerfal, powerful, and indifpenfably neceffary mean of mixtion, compofition, coction and maturation, had at the very firft penetrated into the depths of the earth; and thus, both in the moft effectual and proximate manner operated thereon; as plainly appears by the veins of ore already fought for, and difcovered; thefe being always found fo much larger, by how much deeper they run, and becoming fmaller as they approach the furface; the roots and principal trunks of thefe laft being to be fought for below. And as to roots, trunks and large branches, reafon clearly fuggefts, that thefe principal parts ought to be afcribed to the firft creation: and no lefs probable is it that thofe principal veins alfo, that have at any time been funk for and difclofed, tho' not reaching at furtheft to above 600 fathom deep, or even not to half that depth, may reafonably be derived from that period. Nay, very fmall veins and feams, efpecially if fhooting from larger veins, and thefe again from the largeft of all, may not unjuftly be refered to the fame origin; yet without denying their continuing to ftretch, and, as it were, ftill fhoot out into new fprouts.

Now, if we find the *pyrites*, not only an univerfal indicant of ores, but alfo at the greateft depths, nay moft properly there, we muft allow it, as we do other ores, and even preferably to them, to be as old as the creation. But fhould any one from

from concomitant circumſtances infer the *pyrites* to be the mother of all other ores, he would be convinced of his miſtake, upon being appriſed, that tho' they attend upon, they never are derived from each other. Neverthleſs, ſome preference is ſtill due to the *pyrites*; particularly its martial and ſulphureous parts are ſuch earths, as are proximately derived from the undetermined, ſimple earth, and to which they proximately agree. The ſulphur is originally contained in ſuch a manner in the crude, eſpecially the ſlimey and bituminous earth of the ſea, that to its introduction into the compoſition of *pyrites*, it need only be educed and not tranſmuted. And tho' between bitumen and common mineral ſulphur ſome diſtinction may be obſervable; yet, 1. they are very nearly allied; again, 'tis the iron, not the ſulphur, which conſtitutes the principal, nay the ground-part of *pyrites*: and in regard to the metallic earth, no ſort of ore or metal has any thing in it, between which and an unſpecificated crude earth there is ſo near an affinity, as might be ſhewn in *pyrites* and iron-ſtone. Hence iron is educed without difficulty from loamey, clayey and the like fat earths, by the acceſſion or addition of the *phlogiſton* conſtituting metals: which cannot ſo eaſily be effected for other metals, without mixing the earths employed with other things, and eſpecially without a previous long appropriation, and taking a tedious compaſs about. And the iron-earth of the *pyrites* called *ochre*, ſo nearly reſembles a common, eſpecially a loamey earth, in texture and gravity, that it may well be deemed an earth immediately derived from it: and often their colour is ſo much alike, that the one might be eaſily taken for the other. In ſhort, there is no metal, to whoſe conſtitution an univerſal crude earth more readily and nearly ſuits, nor which ſo eaſily

reverts

reverts to earth, as iron. Now as iron is the ground and principal, conſtituent part of *pyrites*; it follows, that the *pyrites* (together with the unſulphurated iron-ore, or iron-ſtone) is the moſt proximate, metallic ore, which in the beginning might have ariſen from an unmetallic, unprepared earth.

True it is, there are earths, which quickly bear metalliſation for gold, ſilver, copper, lead and tin. But in the firſt place, 'tis here particularly to be heeded, whether for inſtance they conſtitute, as is pretended the gold and ſilver clays, or whether they contain only very tender and unobſerved eyes or ſpangles of theſe metals: again, whether, tho' generally cryed up for their gold and ſilver, they yield only a very ſmall matter thereof; as iron itſelf, eſpecially if noble veins join or accompany its ore; or if in the iron there be pure native ſilver interſperſed, it may be ſaid to contain gold and ſilver; but this is not the queſtion. Further, it deſerves enquiry, whether the gold and ſilver *yields* of *ſinters*; or, thoſe marley, ochry, talcky, and calcarious earths, fermenting and exuding from fiſſures, both in the groove, and often at the *day*, conſtitute their internal, proper mixtion, or only adhere externally, as in a *heap-work*; and thus mixtion and aggregation is here to be well diſtinguiſhed; ſeeing, 'tis well known, that ores, nay native grown metals, do, by means of their *weathering*, loſe their bed, and in length of time, ſometimes their ore and metallic form, and revert to an actual earth; the ſilver to a white, the gold to a blackiſh and grey, which is carried off in a tender earth, in a fluid form, by the waters; and the former never, the latter often obſervable by the eye; and in general, on account of their great degree of tenderneſs with difficulty, if at all ſeparable in the buddling or

waſhing

washing trough. And as the universal, crude earth, not as in the groove, but as at the *day*, seldom amounts to any considerable gold or silver *yield*; iron, on the contrary, is every where to be found in marl, clay and loam, being very tender bodies, and consequently the best adapted for metallisation; and in all underturf, or garden earth infallibly, and that in considerable quantities.

'Tis also true, that we must not deny crude earth sometimes to yield copper, lead and tin; yet more rarely than it does iron. Besides, the tin, that might be collected from the upper crude earth-layers, is not from that earth as such, but from the tin-stone, and *shoads* and grains mixed therein, and thus educed, as from *stream-works*. But according to Tollius's and Barba's opinion, it should be an earth, not only holding, but also generating tin: as the former observed not far from Joachimsthal near Gottesgabe on the confines of Bohemia; and the latter, at Potosi*; tho' instances of this sort are extremely rare. Of copper I have no such examples, if we except the coppery *gurs* or juices in mines, as arising from nothing else but dissolved, crumbled, vitriolescent *copper-pyrites*, and precipitated copper-ochres or rust, also æruginous clays or marls, which have their colour from dissolved copper. And that extremely beautiful smeary Siskin-green, to be met with near Tschopau, deserves a peculiar examination.

As to lead, besides the native grains from Maslaw in Silesia, I have had no other instance, besides what the very leady clays of the Rautencrantz at Johan-Georgen-stadt, there called *lead-spat*, afford, and what sometimes *breaks* here at Friberg,

* Tollii Epist. itiner. pag. 96. Barbæ Bergbucklein, pag. 114.

Friberg, at the Tſcherper and at Tſchopau, in colour ſometimes approaching the rare white-grey, and often to the extremely beautiful green lead-ore: and therefore this leady earth, which is ſomething very uncommon, and hitherto only found in formal veins at the due depth of ores, is to be conſidered as an earth, already peculiarly prepared for particular metals, nay almoſt as a lead-ore: beſides, we may conclude from the vein, which has its *ſelvages* entire and cloſe, and from the extraordinary *lead-yield*, often amounting to 20 pounds the quintal, the vein was formerly an open fiſſure, and this leady clay, as a fluid *gur*, derived from a lead-ore, *weathered* and reduced to earth. Nay the univerſal, upper fatty layer of earth comes near to the conſtitution of iron, ſo that theſe particles of it ſwallowed up by plants, loſe not their fitneſs for metal, but according to M. Lemery's experience, are reducible to a genuine iron, as will plainly appear by the magnet.

Converſely it alſo holds, that all metals are again reducible to earth, yet none more ſo than iron, as it uſually falls entirely to ruſt, ochre and earth by the bare moiſture of the air; whereas for the corroſion of copper a longer time is requiſite; and for lead and tin ſcarce the longeſt term ſufficient: the nobler metals, as fine gold and fine ſilver, neither air nor time ſeem capable of affecting in the leaſt. No other metal is affected ſo ſoon as iron with the weakeſt *depart-waters*, which ſcarce touch other metals; nor are any ſo eaſily reducible to the form of earth, as iron. This may be proved by employing the ſame *additions* for the metalliſation of metallic earths, and *calces*. To which may be added, that no metal ſo readily becomes vitrifiable, or is brought to the higheſt degree of a perfect earth. Whence the *pyrites* is indiſpenſably neceſſary in the buſineſs of

ſmelting,

ſmelting, in order to the act of ſcorification or vitrification, as this laſt operation is for metalliſation. Upon the whole, in iron the metal and the earth ſtand ſuſceptible of the quickeſt, eaſieſt and moſt repeated changes. 'Tis the firſt metal, that may be, and, proximately, is made from crude earth; its earth is the firſt form of all metallic earths, derived from the univerſal crude earth; whence as iron is the ground-earth of *pyrites*, this laſt ſhould ſeem not improbably to have its original as high as the creation. And naturaliſts deviſing another arrangement of metals than that taken from the planets, ſhould give iron the preference, at leaſt with regard to priority of exiſtence, if not of derivation; for by the common diſpoſition of the mineral kingdom, one metal is groundleſsly ſuppoſed to be produced from another; for inſtance, copper from iron, gold from copper, and in this caſe from *pyrites*, and in the language of miners, from mocklead and glitter; a more mature from a more immature, and a noble from an ignoble metal.

To determine the particular time or day, on which the ſubterraneous kingdom took its riſe, or arrived at its ſtate, ſeeing we learn this neither from Moſes, nor any other inſpired writer, is perhaps no very eaſy matter. That actual mineral, metallic *mixts* ſhould, before the ſecond day, lie confuſedly huddled together, ſeems not very probable.

On the ſecond day, the dry land, as Moſes calls it, began to appear, out of the chaos, and acquired its form. Now from this, and particularly the third day, on which the earth was by an expreſs *fiat*, made fit for the production of vegetables, it is ſcarcely to be doubted but that the earthy particles were hereby multiplied, and the tendereſt of them formed, by means of the water, for vegetation; and the more denſe, heavy particles,

ticles, rendered in ſome meaſure fit for the production of ores and metals: from ever varying circumſtances and cauſes, the ſeveral ſpecies of ſtones and ores were ſtill more and more multiplied, and have appeared in the diſorder and confuſion we now find them.

Minerals cannot be put on a footing with the two others kingdoms; as they conſiſt moſtly of dry, but vegetables and animals, of humid particles: the latter may, in ſome ſort be ſaid to be ſelf-produced, ſeeing what they take in for food, is, as if by a ferment, aſſimilated to their juices; whereas minerals grow by a bare external accumulation; wherein every accretion is applied in layers, ſomething like what appears in the cryſtalliſation of ſalts, and in the *pyrites weathered* on *druſe*: and what is thus once accreted never comes into motion, or if it does, not without the deſtruction of the ſubject. The encreaſe of bodies happens alſo in very different ways; vegetables and animals being regularly produced from ſeeds and eggs; but minerals in no ſuch way, no one *pyrites* being thus to be ſhewn produced from another, but at this day neceſſarily ariſing from the very ſame principles with the original *pyrites* at the creation; or from *diſſolved* or *deſtroyed pyrites*; and thus from *pyrites* and ores reduced to their firſt principles, whatever alchymiſts or others may alledge to the contrary. Earth is the mother, and the paſſive; on the contrary, water, as being active and what muſt impregnate, may be called the father.

I wave at preſent, inſiſting on the prejudice accruing to our knowledge of nature from that very unequal diſtribution into three kingdoms; as thereby we acquire a very falſe, or no notion at all of nature, and are apt to run into falſe concluſions about her. If minerals conſtitute no ſiſter kingdom,

kingdom, but be an essential part of their common mother, the earth, how can we pretend to limit their origination to a certain day or period of time, and rather not allow their having existed, in their principal part, from the beginning, and probably from the third day of the creation; tho' afterwards, from time to time, they were extended and became more firm and strong.

The deluge is an event, which has produced the most remarkable alterations in the earth, that have at any time happened, and to which many effects, observable at this day, are to be ascribed. The history of the deluge gives great light towards the knowledge of nature, and the present state of the earth seems to verify this event: by the violence of the deluge the mineral kingdom was thrown into confusion, parts before conjoined were separated, ores and veins dislodged, and new beds and positions given them. The several *strata*, wherein minerals are at present found, afford convincing instances, as well of the truth as of the confusion wrought by this event, especially in parts where clay, sand, shiver, stone and the like, lie in beds and layers on each other. For instance, at Waldenberg, in Misnia, famous for its earthen vessels employed for distilling and other purposes. First, beneath the under-turf earth, which is also stony enough, a coarse, stony sand lies; underneath this again, flints, of the size of hen-eggs, and above these a clear white sand. Thirdly, a middle sand, wherein are nests of *black-stone* with *stone-marrow*. Fourthly, that extremely fat, clear clay, from 2, 3, to 3½ *German* ells *mighty* or thick; and from the under-turf earth, from 10 to 20 ells deep; from which our smooth earthen pots, jugs, and the like vessels are prepared. Fifthly, underneath this, appears a leaner, namely, a sandy sort

of clay, about an ell *mighty*; usually employed for making retorts, and the like vessels, that are to endure strong open fires. Sixthly, a grey sand layer, the depth of which is hitherto unknown. This account, together with samples of the *strata*, I had from a person of reputation, living on the spot. Now here the *strata* are not disposed, as if an effect of the flood, but quite in an inverted order. It is also very remarkable of the Eisleben mines, according to M. Mylius *; that we find, 1. The underturf earth reaching from three to four fathom deep. 2. Loam. 3. Red clay. 4. Blue clay. 5. Fine sand, a fathom and a half deep. 6. Red sand-rock, three fathom deep. 7. A quaggy, soft layer, twelve fathom deep, but not in all places. 8. A loose, spungy layer, three fathom deep. 9. The ashes, three fathom deep, quite to the rock: tho' these layers have happened to be disposed tolerably well in respect to gravity and lightness, coarseness and fineness. In other parts, tho' not in all, of these mines, the first layer is Sod. 2. Earth. 3. Loam. 4. A sort of common round stone. 5. Coarse quick-sand. 6. Red quick-sand. 7. Yellow quick-sand. 8. White quick-sand. 9. Black vein stone. 10. Brown wood-vein-stone. 11. Red vein-stone. 12. Red clover. 13. Red seamy vein-stone. 14. Coarse lime-stone. 15. Lime-stone. 16. Specular lime-stone. 17. Clay round-stone. 18. Loose spungy-stone. 19. *Kneiss*, &c. And tho' many *strata* of earth may have taken their natural positions, yet they never consist of entirely similar particles; and in the chalk, also in the fine clay of Waldenberg are found pieces of the black and grey chalcedon or common flint: yet the deluge has caused great alterations on the surface; as having here covered a country with pure sand, there with slime; also introduced such a degree of confusion, so as to make it scarce possible for each *stratum* of earth to be

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* Mylii Saxon. subterr. P. I. p. 10. & seq.

unmixed with any other, but for the most part to lie huddled and confounded together.

For, we are not to suppose our globe to resemble a trough, or the like excavated figure; wherein the variously mixed earths are to be regularly disposed, as in the operation of buddling or washing ores, but to be of a spherical arched form; where the waters, as on a hanging bottom, powerfully rend and pull it asunder; and this force of the waters we may suppose to be greatest at the beginning, and end of the deluge.

And here we have two circumstances in particular to consider, (1) That the *deeps* of the earth (the cavities and veins being not only broken, but enlarged) were filled both with the bituminous slime of the ocean, the various sorts of earth of the upper surface, and also, with the parts of vegetables and animals. (2) That ores, stones, and minerals, were not only driven inwards by the elevation of the under-turf earth, but also outwards to the *day*, by the eruption of the waters of the abyss, and thrown into and among the under-turf earth; as will appear no ways improbable, from considering the violence of the bursting waters, and that prodigious load of sea impetuously rolling to and fro on the surface. Can it with reason be pretended, that before the deluge any vulcano's existed? or can their origin be ascribed to any better cause, than that, exclusive of the commonly allowed parts of animals and vegetables, it also served to supply the bituminous matter of the sea, as so much new fewel superadded to the sulphureous inexhaustible load of ores already lodged in the bowels of the earth: and further, seeing *volcanoes* are never found except near the sea, may not that immense mass of undeveloped materials serve for incessant supplies to their production?

In and under the upper layers of earth, ores appear to have been sometimes broken off from another place, pushed forth and shattered to pieces; sometimes they have been found complicated, and at other times scattered about, partly in banks or earths newly turned up, as in so many prepared ore-matrixes: and I shall leave it as an undetermined opinion, whether the belief that by the deluge actual head ore-veins, or large constant veins have been produced, be quite so absurd?

And first, as to *shoads*, or broken fragments of veins, we are not in the least to doubt of their being assignable to some violent alterations, of which the deluge alone can properly be supposed the cause. And this seems no ways improbable, from the effects of small torrents, in loosening and carrying minerals up to the *day*; this appears from the gold spangles and grains in some rivers, as in the Schwartze in Thuringia, the Goldsche in the Voigtland, and other waters; in which we often find the minerals themselves shew that they were forced away from veins. And, doubtless, we might also find the ores of other metals, were we as diligent in search for them. Great floods exert a surprising force in vallies, on opposing banks and walls, nay, on rock itself; huge fragments of them being often rolled to a great distance. But what is all this, in comparison to the mighty effects of the deluge, which has tore out of the inmost bowels of the earth, and from depths we can never hope to reach, ores and rock? at the same time, the fountains of the deep were considerably enlarged. Now, as the ores happened to lodge accidentally here and there in the earth, and were occasionally of one and another sort, close and spungey, near to, and at a distance from the great flood-fountains, so also the *shoads* chanced to prove either poor or rich.

This, certainly, muſt be allowed, that theſe ſhoads generally contain tin, or iron-ſtone, or both together; at leaſt, no *ſtream-work*, conſiſting of pure *ſhoad*, is hitherto worked for other metals. If *pyrites-ſhoads* are not always found in the underturf earth, this may be owing to our want of care in examining the upper earth in its ſeveral beds: for, as to *pyrites* in *flat-works*, we have plenty, both *bed* and *neſt*-wiſe, generated either ſhort, or long after the deluge, as ſhall appear below. And at Wiera, not far from Neuſtadt, on the Orla in the Oſterland, a *copper-pyrites* was accidentally found, in digging for a cellar, at the depth of a fathom and a half; alſo in other parts thereabouts, upon digging down from the *day*.

Now this ſupplies us with ſome circumſtances particularly meriting attention. (1) That in this caſe we obſerve neither *flat-work*, nor vein, in which the ore ſhould take its direction. (2) That the ores are not immediately dependent on, or connected with each other, but appear in piece-meal; and though at no great diſtance aſunder, yet, by the interpoſing under-turf earth, are often greatly divided and ſcattered. (3) That theſe pieces, though happening to lie pretty cloſe together, never exhibit any appearance of their having ever been joined, as we often meet with veins, where the ore is cut aſunder with fiſſures, and theſe fiſſures ſo ſtuffed with *gurs*, as if, by their means, the parts had been ſeparated to a greater diſtance; but then, in this caſe, a curious eye diſcovers the parts to have been once joined, and that they plainly formed together an actual vein. (4) That theſe copper ſamples ſhew edges and corners ſo ſharp, that if we ſuppoſe the place they are found in, not to be that of their birth, yet it could be at no great diſtance off, if we conſider that ſuch broken fragments may, by rolling, become ſmooth, and wore round. But

But we need not go ſo far for inſtances; ſeeing in the *tin-ſtream-works* of Friberg, the *tin-ſhoads* are often intermixed with *pyrites*, as ſmelters find to their coſt. Should we allow the *pyrites*, from its ſuppoſed univerſality, to manifeſt itſelf in many places as a *ſhoad*; yet it muſt alſo be allowed, that this mineral, above all others, is moſt ſuſceptible of deſtruction, and of becoming an earth again; eſpecially if lying near the *day*, and thereby more expoſed to the action of the air; ſo that in the courſe of ſome thouſand years, many teſtimonies of the deluge may be quite effaced. Further, that this ſurmiſe is not without foundation, may be concluded from the ruſty ſpots and neſts found in many places; in particular, thoſe in ſand-ſtone, ſhew remains and tokens of *weathered*, or deſtroyed *pyrites*. Nor are we to wonder, that *copper pyrites* is more commonly to be met with than *iron-pyrites*; ſeeing the former is generally more durable and laſting, if not ſometimes indeſtructible.

Again, it will be no difficult matter to form a judgement, and ſhew the weakneſs and inſufficiency of the remarks generally made on *ſhoads*. Thus much commonly holds true, that, the ponderous and moſt metallic ſort cannot eaſily remain near the ſurface, but muſt ſink down. Concerning pieces of ore which happen to be ſmooth or ſharp, we may probably conjecture, whether the vein, whence they came, was at hand, or at a diſtance: if the ſtone thereof, or of the adjoining mountain, be the ſame with that of the *ſhoad*, we may imagine the vein to lie there, and there we may work for it; and *ſhoads* in high mountains, and on eaſy declivities, are more eaſily come at. But every one ſees how fallacious ſuch indications or directions are; for ſuch broken fragments may, in a tender bottom, be driven to

a sufficient distance, without having been in the least broke off, or smoothed.

I must not omit mentioning, on this occasion, that usually, under the title of *pyrites-shoads*, we also include the *squats*, or *flat-works*, which are commonly *copper-pyrites*, and justly; as these, with their upper and under earth-layers, are couched in *strata*, one upon the other. To this Lohneiss refers *, when he says; 'we also find '*squats*, which extending in length and breadth, 'often take in a large compass of rock, which 'we call *shoad*, &c.' but with this remarkable difference, that on such *flat-veins*, not the ore itself, as is the case with the *shoads* hitherto described, but only the earth, whereon afterwards the ore comes gradually to be generated, is thus couched and laid.

As to *flat-veins*, these, in regard to their origin from the deluge, deserve a quite different consideration. Sand-stone, lime-stone, marle-stone, and shiver, which generally form *squats*, plainly manifest, upon a somewhat more accurate inspection, that they are a concreted sand, or hardened earth. The several figures of herbs, wood, bones, shells, and fish, are far from being *lusus naturæ*, or fortuitous images, but are, in part, actual bodies, somehow or other conveyed thither, or, at least, the impressions of these bodies. This I have shewn, from several circumstances, in my *Flora Saturnizans*; particularly from the nature of their beds or matrixes, from that of the bodies themselves, which are commonly durable, hard, and stoney. And here I must rectify a mistake I was there under; namely, in not allowing the *hystero-lithos* to be an actual species of mussels, and doubting about the *glossopetræ* being the teeth of sea-dogs;

* Berg-baa-buch.

dogs; but now I am fully convinced of the certainty of both: of the former, from a particular treatise of M. Verdries; and of the latter, from many instances; in particular, from my own inspection of a sample, to which there still adhered a piece of the jaw, in the possession of Dr. Buttner, of Chemnitz. Further, from the substance and nature of such fossile bodies, remaining, often, quite unaltered, their origin is plainly manifested; also from the *mixt works*; and, lastly, from their irregular position; in reality, not owing to their natural tendency, but to some external, irresistable force; whence it is no improbable conclusion, that nothing less than the universal deluge could have buried the parts of animals and plants at such a depth in the earth.

Now as both the *copper-pyrites*, and also the often intermixed *iron-pyrites* flat work lie in, under, and above such petrified remains of the deluge, how can we *here* possibly go so far back as the creation, and *there* begin with the deluge, or call in question the existence of such ore in that very place and spot before, and only allow its having arisen first of all after the deluge? three circumstances which, if not entirely convincing, yet, being of some weight, render the thing probable.

The first regards the *strata*, or beds of earth, constituting both the under and upper bed of the *pyrites*; some of which I have before mentioned, from M. Mylius, and others: these lie in different forms, in various shelves, or *strata, cover-wise*, one over the other; which we may justly attribute to an horizontal, or level motion, and this motion to a floating or wavy flood. The undermost often reach to 10, 20, 30 fathom, and more; so that they cannot be ascribed to any partial or provincial inundation: and lastly, they shew their se-

paration from the *terra firma*, or that bottom, which before the deluge conſtituted either the upper ſurface, or was, by means of the deluge, firſt tore up, and laid bare.

The ſecond regards the nature of the *ſquat-ſtone* itſelf; for now to mention only *ſhiver*, in which the *pyrites ſquat-veins* are moſtly diſcovered, we muſt needs ſuppoſe them to have been originally a water-ſlime, gradually arrived to a leafy or flakey ſtone, as was above ſolidly deduced from the extraneous matters found therein; it being impoſſible they ſhould have their preſent degree of firmneſs and hardneſs, and at the ſame time receive ſuch matters as theſe: and the nature of *ſhiver*, eſpecially the aluminous, might ſerve not a little to eſtabliſh this, as being inflammable, and like a fatty ſort of ſlime; nay, not unuſually manifeſting in the fire, a flame, and odour like amber and bitumen. Nay, 'tis hard to ſay, whether (3) this other circumſtance may not be allowed ſome weight, namely; as lime-ſtone ſo readily break near *ſhiver*, and are, above others, of a ſaline nature; again, as lime-ſtone, ſhiver, and ſtone-coal, are not eaſily to be found, the one without the other; alſo, as lime-ſtone has actual ſtone-ſalt lodged in and upon it, of which we have a ſample at Bottendorff, in Thuringia: laſtly, as the ſea, particularly in its depths, abounds with ſaline, bituminous, and ſulphureous particles: and beſides, as ſalt and ſulphur, ſulphur and ſalt, ſalt and earth, ſtand ſo proximately convertible; ſhould we not, from all this, conclude, that ſhiver, ſtone-coal, and lime-ſtone, may have had, from the ſea, one common cauſe, both of their mixtion, conſtitution, and bedding?

And as ſuch *flat-work* ought not to be derived from the creation, ſtill leſs is it to be conſidered as a genuine *ſhoad*, or *piece-meal-work*, thrown together

gether in a heap; in regard it not only, tho' cut through with crofs fpads, fiffures, and minerals, hangs together like a thread, but it alfo often appears fhattered and tender as hair; the deluge, firft, only fupplying the proper flimey earth, as the ground, or bafis, which not only became full of fiffures in the drying, but is in itfelf alfo an accumulation of a fpungey and eafily penetrable matter. In the fiffures, the *ore-weatherings*, or damps, have found ingrefs and lodging; but in the particular fort of the earth, found a well prepared, alfo an expanfile matrix; and for this purpofe, nature has had a fufficient fpace of time, as being what was highly requifite; but why fhe has excluded or produced no other ore but *pyrites* chiefly, in particular, *copper-pyrites*, is indeed a queftion we are as little obliged to refolve, as the remote caufes of things are beyond our inveftigation: however, a caufe may be affigned, on which we may beftow the following reflections.

We find both earth, *heap-work*, and ftone, nay, ore too, in layers. Of the firft we have, every where, inftances enough; particularly in fand, loam, and clay-pits. Of ftone there neither is, nor can be fo much known; feeing both our experience and accounts thereof are lame and imperfect. In ftone-quarries, however, we plainly obferve layers; yet, commonly, not fo often of a different, as of a fimilar nature, where neither complexion, nature, nor colour, exhibit peculiar layers, only the feams form different flakes and tables, the whole mafs of ftone having only a cover and bed of a harder nature. Again, in complexion, and thus in admixture, alfo in nature, namely, ground-mixtion, appears a difference of the ftone layers; as quarry-ftone, fand-ftone, limeftone, &c. may well lie interchangeably together: and not only in thefe large *ftrata* of earth and

ftone,

ſtone, which take up a large compaſs, but alſo in peculiar ſmall ſeams and veins, traverſing ſuch large *ſtrata*, often various layers are obſervable.

Of this miniature *flat-work* ſtone, if I may ſo call it, we have an extraordinary inſtance, at Friberg, in the uncommon jaſper, or coral ſtone. For, there we have (1.) a white, heavy ſpad. Under this (2.) a ſmooth mountain-cryſtal, both of them from 1 to 2 inches thick. (3.) Amethiſt. (4.) Again, mountain-cryſtal, or *quartz*. (5.) Jaſper. (6.) Mountain-cryſtal. (7.) Jaſper. (8.) Mountain-cryſtal. (9.) Jaſper. (10.) Cryſtal. The former eight layers are often only the thickneſs of a fine thread, and all together ſcarce exceeding ¼ inch, and yet very diſtinct. (11.) Jaſper, of a bright red. (12.) Jaſper, of a dark red. (13.) Chalcedon. (14.) Jaſper. (15.) Chalcedon; nay, the two laſt, once or twice more, alternately. (16.) A firm horny quartz. The laſt ſix or eight grow ſtill thicker and thicker, the jaſper there being often an inch thick, and above. Theſe layers of precious ſtone, which are extremely beautiful to the eye, cohere very firm and cloſe together, ſo that the entire ſtone bears ſplitting tranſverſely, better than in the ſeams; and then they lie not ſo flat in ſhivers on each other, but vaulted one over the other, with ſmall arches, ſo that the thickeſt layer of jaſper may be clearly ſeen to traverſe moſt of the upper layers, till, at length, it gradually loſes itſelf: yet there the jaſper-layers are moſt eaſily ſeparable where thickeſt, alſo where the chalcedon is thickeſt: and as it there exhibits pure round eminences, ſtanding cloſe to each other, like ſo many little balls cut aſunder, whoſe concavities lodge in the chalcedon, it is here, at Friberg, commonly called *coral-ſtone*. In particular, the violet caſt of the amethiſt, and the red bluſh of the jaſper, whereby it comes to reſemble coral, would

would ſeem to ſuggeſt an enquiry, whether their tint be not owing to the ſhare of metal they contain. I know not, whether the amethyſt does not hold gold; as there is no experiment extant for giving ſuch a violet colour to a ſtone, or ſtony glaſs-flux, except by the means of gold, with the addition of tin; eſpecially, as I have a method of imparting this colour laſtingly to ſpring-water, without making it leſs ſweet and potable, from gold, without tin, or any other mineral, or metallic body, barely by means of a certain ſalt. As to the jaſper bluſh, I would mention iron, as, at leaſt, the earth of this metal eminently carries this colour; or even gold, either ſeparately, or jointly, with the former, none of theſe circumſtances being inconſiſtent with the nature of things. All this I propoſe as conjecture only; for tho', indeed, neither gold, nor any other metal, is, by analyſis, or reſolution, educible from ſuch amethyſts, *quartz*, and *druſe*; nay, is as little poſſible, as that the leaſt trace of a metal ſhould be manifeſted by the quickeſt, moſt tender ſcales, in artificial, variegated fluxes and glaſſes, from the metal being widely diſperſed; and to be educed from glaſs, a body the moſt tender and retentive, and to be exhibited in its metallic form: yet, *ſynthesis*, or compoſition, gives ſome countenance to the conjecture; namely, as the well known gold-purple, or the gold powder, made with tin, bears being introduced as a violet colour into glaſs, nay, into a common water: this I the rather mention, ſeeing in chemiſtry, and according to the doctrine of nature, the proofs from compoſition are preferable to thoſe from reſolution. But be this as it will, the different *ſtrata* in this jaſper-ſtone manifeſt ſomething different, if not in the ground-mixtions, yet in the degrees of the coction and maturation of the mixts; the *ſtrata* not being produced externally in couches,

couches, in the ſame manner that floods may be ſuppoſed, from time to time, to accumulate different layers of earth, ſand, &c. on each other, but ſpontaneouſly, from a vaſt number of earthy particles, in the way of a precipitation, both by means of the ſubterraneous inſtruments of maturation, and thoſe of the moiſt, warm air, this ſtone ſtriking out quite to the *day*.

For, there is no one *ſquat*, where a flood, the moſt partial imaginable, can be exhibited as a cauſe; but dipping into the *deep*, and ſtretching, as it does, into the *field*, it is over-laid with the abovementioned variegated ſtone; in reſpect of which it may rather be called a vein: and accordingly it takes its riſe from the bowels of the earth, and, probably, in the way of an exudation, or fermentation; at the cloſe of which, the refuſe, like dregs, ſeparates upwards and downwards, the nobleſt parts remaining in the middle.

Yet, not to digreſs too far, we muſt here diſtinguiſh between thoſe *ſquats*, once really formed by the waters of the deluge, and thoſe ſpontaneouſly and gradually produced before or after it, barely by length of time. The former are either unchanged earths and ſands, or become firm, and thus turned to ſtone, as the ſhiver and ſand-ſtone, chiefly here at Friberg. The latter are partly the harder and cloſer ſort of ſtone, as *gemſs*, *knauer*, and all thoſe banks, or ſhelves, chiefly coinciding with the deeper under-lying ſtone; partly fermented, or exudated, petrified, mineral juices. Of the ſecond ſort, being, at preſent, foreign to our purpoſe, we ſhall treat hereafter. As to the firſt, we ſhall now offer ſome anſwer to the queſtion ſtarted above; namely, why, in the *deluge-ſquats*, we commonly find the *pyrites*, and, more frequently, the *copper-pyrites*. Tho' this queſtion may ſeem ſomewhat premature, conſider-

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ing the ſmall depth of earth we have hitherto had occaſion to lay open; our experience, however, reaches thus far; that what lodges in ſhiver, is *pyrites*, and that at all times. We here ſpeak of capital *ſquat-works* as of veins, over-looking, as of no account, the inter-current ſmall fibres of *glitter*, and ſmall interſperſed eyes of ore: for, where was there ever a *ſhiver-ſquat* of *glitter* laid bare, where this laſt was the eſſential, conſtituent part, and the *pyrites*, either not at all, or only incidentally in it, as, we know, is the caſe of veins dipping extremely deep? or where did we ever hear of noble veins of *red* and *white goldiſh* ore, *cobald*, *biſmuth*, *glaſſy* ore, and the like, in ſhiver-mines, unleſs in tranſverſe veins?

Pyrites chiefly conſiſts of iron and ſulphur; now we find ſhiver exactly to correſpond in theſe two conſtituent parts of the *pyrites*, if not eſſentially containing them. Above all kinds of ſtone, it contains ſulphur, nay, often that alone; as plainly appears in *alum-ſhiver*, *ſtone-coal-ſhiver*, and the like black bituminous bodies. To the formation of iron all fat earths are adapted, nay, all earths, ſo they be capable of being duly combined with the *phlogiſton*. Iron is the moſt univerſal metal, as I have repeatedly ſhewn already; is the primordial metallic form, producible the moſt readily and eaſily from an earth: iron comes neareſt the nature of the inflammable earth, as appears from its deflagration with ſalt-petre. Sulphur and iron are the two capital, middle mineral, and metal ſpecies, as undeniably appears from all conſiderations, whether œconomical, medicinal, and purely natural; that were we to ſuppoſe any one metal or mineral produced expreſs, theſe two may, above all other ores and metals, be affirmed to be ſo. Again, what is *copper-pyrites* in ground-mixtion, but *iron-pyrites?* and tho', on the ſcore of

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the excess of the copper, which may sometimes amount to almost half the ore, it usually quite loses the appellation, *iron-pyrites*, yet, the quantity of copper with the iron is inconstant and variable: for, *iron-pyrites* may well be without any copper, as those of Hesse, Boll, Altsattel, Toplitz, &c. sufficiently shew, but *copper-pyrites* never without iron. And should this be allowed of no weight, yet what has a greater affinity with iron than copper? We have often *copper-pyrites* veins, without the least *lead-glitter*, much less any other ore, either attending or intermixed: but where is there any other mine, without a number of different veins, either accompanying or intermixed, and without any *pyrites* at all? Iron and copper cohere so firmly together, as often to be scarce separable, as the Strasburg undertakers experience to their cost, at the Lower Hartz, where there lie some hundred quintals of metal, as 'tis called, or black copper, holding 56 lb. of *rose-copper* the quintal, and 4 loths * of silver: nor can they, with much more facility, separate the grey iron-stone (containing 30 lb. of iron the quintal, and tainting the copper) from the copper-ore. Copper, next to iron, above all the metals (if we exclude zink, bismuth, and regulus of antimony, and perhaps also tin, as belonging to the class of semi-metals) manifests the largest share of *phlogiston*; not to mention other circumstances, too tedious here to enumerate.

The question may be resolved by proposing another, namely, why in other ore-matrixes, as for instance, sand-stone, loam, and the like, which, equally with shiver, are derived from the deluge, there are not also *pyrites-squats*. To this the answer may be, that all such queries are premature, and ought to be forborn, 'till we can assert, they

* A loth is half an ounce.

have

have been duly ſunk, or dug for, without finding any thing of that ſort. In the famous ſand-ſtone quarry, at Pirna, in Miſnia, the common ore-depth has not been hitherto reached; and what pity is it, that ſo extraordinary a quarry ſhould not be more carefully examined? The loam-beds, likewiſe, have equally partaken of the ſame fate; namely, to lie neglected and unexamined.

Now, tho' our experience, which is, hitherto, inconſiderable enough, ſhould ſuffice to give the preference to the *ſhiver*, above other *ſtream-beds*, in regard to the *pyrites-ſquats*, yet it would be no difficult matter to find out ſome reaſon for this difference; namely, thoſe parts proper for the mixtion of *pyrites*, as the fat earth for the ſulphur, and the tender earth for the iron, as has been already mentioned, are found, eſpecially the firſt in the ſhiver, not only proximately prepared for the *pyrites*, but alſo indiſputably in greater plenty than in loam and ſand: and the matrix is not to be conſidered as a bare receptacle, but as a receptacle of proper materials too; that is, the inhalations, or impregnations, called *inweatherings*, cannot alone have their effect, nor their ſupplying their materials produce an ore, unleſs the matrix hold, and reciprocally furniſh alſo, by means of an exhalation, called *outweathering*, its proper matter; that the paſſive may, by means of the agent, come into motion, to form the third body here intended. In loam, 'tis true, a fat earth is contained, from which iron may be, and actually is produced; but naturally not in ſuch quantity, as that the iron ſhould put on the form of a *pyrites*, and it is the ſame with a body over-doſed with ſulphur. In the ſand-ſtone the parts of the whole have too far deviated from the nature of an earth, and arrived at ſuch a degree of hardneſs, to be incapable of a greater remove from the form of an earth, from which

which orey and metallic particles are to take their rise: for, this ſtone conſiſts of pure ſand-grains, which are ſo many ſmall flints, and, conſequently, the denſeſt corpuſcles; and like ſo many hardened, indurated matrixes, where the effete materials are, even by the ſtrongeſt influx, with difficulty brought to motion and conception. Yet here ſome might conſider, as oppoſite to this, the commonly flinty and quartzy, nay, horn-ſtony rock of the *ſelvages*, which, in veins, form the caſe for the ore. But, not to mention that objects lying near are not always to be ſuppoſed derivable from each other, tho' they may ſucceſſively, or even ſimultaneouſly, happen to exiſt; the principal reflexion and query here may be, whether ſuch quartzy and horn-ſtoney rock was already become ſuch a denſe and cloſe body, when the ore began firſt to be lodged there? or whether it was not of a moiſter, ſofter, and a more réceptible texture, wherein the mineraliſing *weathering*, or damps, might find lodgement, incorporate itſelf, and thus the tender veſſels of the matrix, namely, the tender *ſelvage*, emit ſome material efflux for the production of the ore? The firſt opinion fails, for this reaſon; as it muſt be allowed, that this ſtubbornneſs in the earth was not original, but adventitious; and that ſomething flinty, quartzy, ſandy, ſtoney, glaſs-yieldy, or, in a word, Becher's firſt earth, might not exiſt in metals.

And in thoſe productions of the *pyrites*, for which the deluge has laid the foundation, ſomething peculiar is ſtill to be obſerved: namely, that *pyrites* is even found weathered on bodies at a great remove from the mineral kingdom, and unadapted for it, as wood; of which I have both ſeen and read inſtances. M. Lichtwer of Dreſden, Inſpector of his Majeſty's cabinet of minerals, has a ſmall piece of wood, on which a glit-

tery,

tery, mock-leady matter was not only manifestly weathered, but lodged in its rents. This sample, which was found in 1658 in an old mine at Schwartz in Tyrol, manifestly shews, it was not only a real unpetrified wood, but also the ore so closely adhering to it, as to exclude the least suspicion of a cheat or imposture. And this has led me to enquire farther after such samples; at least, whether ore may not sometimes have been found on bodies, tho' of an extraneous kingdom, yet approaching nearer the nature of stone than wood does; as for instance, on periwinkles, muscles and the like shells, unchanged, unpetrified; though that such parts are also petrified is evident from the fossils of Boll in the territory of Wirtemberg. And I have seen the muscle-work of Wicrau in Osterland, on the Orla, a mile from Neustadt, stuffed with sand-stone, in which lead-glitter was implanted deep into the shell, but still distinguishable and separable from the adhering sand-stone; tho' I considered it rather in a petrified than in a native or animal state. But we experience this still more in wood petrified, or reduced at least to stone-coal; M. Mylius, among others, insists upon having seen samples of that kind, filled with marcasite, from the Fischbach in the territory of Henneberg; and pieces of wood, reduced to marcasite, have been found at Leipsick and Bitterfeld, in digging for wells*. Yet such instances, where pieces of shell or wood are become real stone, are immaterial, however extraordinary, in other respects, it might be to find lead-ore, near such fossils, as it would be no less so to find lead-ore in sand-stone. And tho' there were no samples of the *pyrites*, or any other ore to be shewn on the unchanged remains of the deluge, yet such might not come to the *day*; of which the above sample of wood, overlaid

 with

* Saxon subterr. P. I. p 63.

with glitter, appearing but very lately, is a plain inſtance; and as experience ſhews, that many things carried off and buried by the deluge have retained the nature of their reſpective kingdoms undeſtroyed: tho' the bodies of vegetables, in particular, are of ſo watry and changeable a mixtion and texture as to be incapable of any length of duration, they turning either to earth and aſh or ſtone, and thus either degenerating or improving; yet in many places they have preſerved themſelves from corruption: and bones and ſhells have undergone a kind of calcination, and wood a hard exſiccation. I have, however, had ſamples, clearly exhibiting parts of animals, in their unpetrified form and mixtion, ſuffering *pyrites* to grow upon them, and thus rendered ſuſceptible of the action of a mineral weathering or damp; nay even more ſo than in vegetables.

Tho' we might well poſtpone this article to the following paragraph, where it will appear, how the *pyrites*, without any action of a deluge, may be ſuppoſed to be generated barely by length of time, and is ſo at preſent, to ſay nothing of entire large veins; tho' there is a great deal of room to think, that all of them are not abſolutely referable to the creation, as to their origin, but that here and there, amidſt the never-ceaſing, violent working of the huge maſs, there muſt needs have happened large waſtings of ores, and ſpringing or ſplitting aſunder of whole rocks, and that theſe ſtill happening, may be attended with new productions, in order to the filling up theſe rents or gaps: yet having already real teſtimonies enough to verify the opinion of the new production of ore, it would be needleſs to call poſſibilities in aid. In the firſt place, ſinter is found with its glitter and *pyrites* upon it, not only in ſome old mines at Friberg, but alſo in various places, in caves, and even

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at the *day*: by finter is meant, in the full extent of the word, all thofe earths in the *groove*, which, by means of the gentle motion of the waters, work out and exude from the fiffures (whence they are called *gur* *) and thus accumulate; turning thick and fmeary, a part hardening to ftone, and forming icicles, a part remaining earthy and foft like butter, according to the difference of times, place, the nature of the earth itfelf, and other circumftances. The laft fort confifts commonly of an ochry, yellow and brown fubftance, and doubtlefs is only the metallic earths of *pyrites*, fomewhere or other weathered, or diffolved; its earth, by that deftruction, becoming highly tender and light, fettles downwards on fiffures, thro' the water, and alfo mounts upwards, in its tendereft parts of all, to the *day*, as is known to be the cafe of moft medicinal fprings. The firft fort is more of a calcarious or fpathy white, not fo common, and probably derived from fome fuch rock, which, if not a pure lime or gypfum ftone, yet partakes of it; at leaft, quartz or the like, it cannot be: this we fee from its refolution, particularly by its ignition and extinction; where, by the lixivious odour, by the crumbling and extraordinary degree of whitenefs, it bewrays its origin: again, from its compofition, when the waters in vaults, and adjoining to walls, (whereof, among others, the great aquæduct, called *balfebrucke*, near Fribourg, is a plain teftimony) let fall again the lime, unobfervedly conveyed along with them, and re-apply it to the roofs and fides, in flakes and icicles; yet with this difference, that fuch a finter, as at the *day* even in places, that feem pretty clofe, and yet not altogether fo, as quite to exclude the air, arrives not to that degree of firmnefs and hardnefs, like what fuch a one has, that proceeds from

* From the German *gieren*, fignifying to ferment.

grooves quite run to decay, or not immediately exposed to the fanning of the air.

Moreover, we are to observe this circumstance, which gives a great degree of probability to our notion of both these sorts of sinter, *viz.* that the white, like a lime, binds as easily as stone, which the yellow, being metallic, does not: yet it should be remembered, that we are to except the luty or talky *sinter* or *gurs*; such as, in particular, are to be met with, very beautiful, on the Himmelsfirsten and Gunther, at Weissenborn; but which is not so much of a lime, as a grey-silver white, and does not petrify. In short, the *sinter* is either luty, and of a marl-earth; or metallic, chiefly from iron; or calcarious and petrefiable. Of the third sort, namely, that frequently called *stalactites*, or *stalagmites*, drop-stone, and which must be well known from the famous Bauman's cave, is not so uncommon in mines, provided we are attentive enough: yet, so far as I remember, it is no where found, in the territory of Friberg, so plentifully as at the mine called Himmel-farth-christi; nor, indeed, can it be so common, seeing, in the first place, old decayed mine-works, and moreover, certain waters, must concur to its production; and *there*, upon due observation of only the nature of the *sinter*, the most pertinacious in opinion must drop the period of the creation for its first origination; for, *there* the fissures, the sides, and roofs, are covered over with a stony shell, or crust: nay, what is very extraordinary, the water in a pit of the groove, when full, was covered over with a stony crust, as with a thin ice, the thickness of the back of a knife, and tho' loosened at the sides, still remained floating upon the water, whence it was called *floating sinter*.

On such drop-stone actual *lead-glitter* has been found, two samples of which I have in my own possession;

possession; and many other instances I have observed of the production of ores and *pyrites*, even lately: as, a *sinter* from the territory of Hohenbircke, from the greatest depth hitherto reached, exactly overlaying a *drusy* lead glitter, and the latter, a *sinter*, and this *sinter*, *lead-glitter*, as so many pebbles, or buttons, artfully accreted to each other. I am possessed of a *sinter*, whereon the *pyrites* is visible, and in particular, the coppery; nor do I doubt but many more such instances may be hereafter met with, when application is made to these subjects, with more accuracy and attention;—so that *sinter* is still at this day produced in places where before there was none.

It may seem needless to mention particular instances of this kind, seeing earth is known to be derived from water, and stone from earth. Examples of waters yielding stone are very numerous. The Caroline waters at the Prudel deposite a whitish, intermixed with a flesh-coloured, and throw up a yellowish stone, firm enough to bear working and polishing, like marble; and that in such plenty, that the inhabitants are, at times, obliged, not without great labour, to remove it, to prevent its choaking up the spring. At Merana, in the County of Schonberg in Misnia, there is a stone-quarry, where we have a plain instance of the same sort: the stone is done over as with so many crusts of ice, and directly beneath the under-turf earth huge masses of *sinter* are dug up. *Sinter* continues growing so long as that sort of earth, whereof it consists, is conveyed to it by the waters, and the free access of the waters not interrupted by the entire concretion of the fissure, or by other accident. The first is evident from all the abovementioned instances; in particular, the Caroline stone, which may be daily observed

accreting more and more according to the things laid therein; alſo to fiſſures and cavities, which often become gradually narrower, and, at length, are entirely blocked up. The ſecond is alſo very plain, as an increaſe always implies a free acceſs; and, as evidently appears, among other things, in *mixt-works*, ſuch as I above inſtanced in from the Hohenbirck groove, where we ſee, that where the ore and glitter, forming *weather* or damps, have, as it were, ceaſed, the ſtone-forming, or petrifying waters, begin to overlay the *glitter* with a cruſt of *ſinter*; and this again ceaſing, the *ſinter* to afford a couch to the *glitter*.

Here I muſt not omit mentioning, that this ſtone forms no layers or ſhelves, tho' its accumulation be by a ſhoving of earthy particles precipitated out of the waters, over each the other; whence it ſeparates, not in flakes or leaves horizontally, but rather upwards and downwards; alſo, in breaking, it manifeſts a texture, ſhewing its increaſe to happen ſideways, by an appoſition of tender threads, almoſt in the manner of the Hungarian *atlas-vitriol*. For, from the *ſinter* from walls, and thus from lime already prepared, which eaſily bears being divided into flakes, we cannot conclude to that which is derived from crude lime-ſtone, and other unknown admixtures. My reaſon for mentioning this, is to obviate ſome miſtaken notions about the Caroline white-coloured ſtone-ſtrata, which are evidently diſtinguiſhable from each other, not only by the colour, as being beautifully ſtriped like a piece of cloth, or fillet, but alſo by their eaſy ſeparation at the coloured parts: and, doubtleſs, the different colours ſhould afford ſomething different in their internal *mixtion*, at leaſt in the proportion of it, upon making a due proof of ſome of the principal *ſtrata*, each apart.

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On this *sinter* then, thus lately formed, and still forming, even to this day, we find *glitter*, iron and copper *pyrites*, not conveyed by streams of water, nor agglutinated, but *weathered* thereon, or produced by *weather* or damps. This I affirm, to obviate a doubt the reader might otherwise entertain, from pieces and bits of ore being loosened either spontaneously, or by men's hands, from veins, and conveyed along by the waters, coming somewhere or other to lodge and fix, and to be concreted, not only by petrifying waters, but also by binding *weather*, or damps: and I have had samples, where such concretions, by waters, of pieces of stone or rock, was very visible: nor is it any new thing for the damps of ores and stone to fill up again the rents and chaps in *vein-stone*. The ore on *sinter* is a plain and easy proof in behalf of a *weathering*, or a production by damps, rather than by way of *streaming*; for, (1.) both the *glitter* and the *pyrites* appear in as compleat, cubical, and angular figures, as they do on quartzy and spathy *druse*, where few will readily admit the effects of a *streaming*, and as little doubt of those by damps, as shall be shown lower down. (2.) I never once met with any one piece of ore, either on *druse* or *sinter*, tho' I have accurately examined a great many samples, where the piece in question manifested any flaw; all of them, even the smallest bits, having their proper smooth surfaces and sides, as the most indisputed original *mixtwork* could possibly have. (3.) There must needs interpose a manifest band or cement, either proceeding from the mutual action of the bodies themselves, or from an external *weathering*, or from water, to bind them together; and yet, between the *sinter* and the ore no such third body is observable to form the band or cement, the ore lying immediately pressed in upon the stone.

In short, the *pyrites* of such places is a new production; and its foundation being but lately laid, how can the superstructure be supposed to be of an older date? The *sinter* manifestly is produced as it were before our eyes, and shall the ore then, found thereon, be made coeval with the world? *Sinters* claim our special regard; and, without vanity, I may affirm, that, as far as I know, no one, before myself, hath ever made the observation of ores growing on them.

This leads us to consider, whether ore may not be found successively generated in *druse*, in nests and fissures, rather than on *sinter*: as, (1.) such matrixes are more adapted for the conception of ore, from their flinty, quartzy, and consequently more appropriated nature, than calcarious, spathy *sinter-stone*: besides, that the *ore-weatherings*, or damps, lie more undisturbed in such close matrixes, than where the *air* is in motion. (2.) As there are not wanting *sinters* in *drusa*, whereon, again, ore accretes. (3.) Should we only consider, why those *druse* exhibit, if not always, yet commonly, and very plentifully, their ore, which is, for the most part, *pyrites*, on one side only; must we not thence conclude, that what thus adheres to the *druse*, did not at the same time arise with, or spring from it? Again, that matters, thus brought together, may have had their origin and flux from that side whereon they are found; and, lastly, that they were applied thereon by *weatherings* or damps? And can we imagine productions, of which often two, three, or more species are found lying on each other, to spring, either altogether, or instantaneously?

From the most unexceptionable experience, we learn the clearest and purest waters to hold and carry along with them earth; afterwards, to let it fall; further, this earth to turn to stone; lastly, and prin-

principally, these stones to prove as crystalline and transparent as the clear tacks or spikes on *druse*; as appears from the following experiment. Take the fresh urine of a boy, leave it to stand for three or four years in a staunch, large cucurbit, about half full, covered over with a bladder, on a shelf, in a room of so temperate a warmth, that scarce any thing shall evaporate (tho' it be impossible but some should) but only amidst tender mounting steams, trickling down again in drops, the least distinguishable separation, that can be procured. Now, after hitting on the proportion of the vessel, and the due degree of warmth, there will accordingly be observed, sooner or later, after the precipitation of the very gross, tartareous, earthy particles from this water, above on the rim of the glass, small, white, oblong stones, of the length and size of oat-grits, adhering so firmly to the glass, as to remain undisturbed upon decanting off the urine. The first time I came to observe them, I could have averred them to be a crystallized salt; but, upon rinsing them carefully out, they evinced nothing saline on the tongue; nor, according to the known quality of salt, did they admit a solution in the hottest water, so that they must be pure crystalline pebbles, oblong and prismatical, like nitre; figures that the quartzy tacks on *druse* exhibit mostly, and of which I procured a drachm from six lb. of urine. This stoney matter, which may properly be deemed Becker's first earth, appears also in the actual salt of urine, when melted to a glass. And here we see how excellently, and how far, long digestion, nay, even only time and patience, avail in producing forms and effects, generally deemed impossible, and seldom looked for in elaboratories, except in those of nature; whence such stoney matter should be generated in human bodies, is not difficult to be accounted for, when

when we consider the seeds of it may be conveyed along with the water we use.

'Tis true, a very small matter of the tender essential salt of urine is incorporated in these small stones, as may be easily observed by its volatility, and extraordinary agreeable smell, upon ignition; yet so incorporated, nay, fixed as it were, that neither the taste can perceive, nor hot boiling water extract any of it. Moreover, it is impossible to exhibit either a saline, or other water, whether natural or artificial, containing earth, that ever yielded the like crystals; all the vitriolic, aluminous, nitrous, &c. waters, always shooting into their own proper saline crystals, be the time appropriated for that purpose never so long; yet, with this remarkable difference, that the longer time they take to shoot, the crystals prove much larger, harder, more durable, and so far approach nearer to the nature of stone; but, in a pure, insipid, earthy water, tho' standing never so long, no experiment to this purpose is extant; and indeed, from waters entirely devoid of salt, no such thing is to be expected, as they want the requisite cement, or interposing substance.

The shiver-mines of Ilmenau in Franconia, afford those well known bodies, called *kidneys*, of an oblong oval figure, and enclosed in shiver, as in a shell. In these we often find, together with the figures of fish, figured cavities, often containing a clear water, bearing the impressions of ears of corn, spray of the pine-tree, or rather, a kind of coral, the circumference of which is set round with small, transparent, white stones, like sugar-candy; and tho' these stones may be easily crushed under the teeth, yet, in the fire they lose nothing of their hardness or transparency. Now 'tis impossible to imagine these small stones were originally created, the circumstance of the water contained in the ca-

vities probably ſuggeſting their having ſhot from that water, like a ſalt.

Nor will it ſeem unnatural to view in the ſame light the *druſe*, or thoſe cavities candied over with cryſtals and variegated ſtones, tho' we could not by art imitate their beauty, ſize, and firmneſs, for want of the proper means and opportunities for that purpoſe. It may be preſumed that the earth was, at firſt, a ſoft, yielding, ſpongey body; that, by the gradual ſeparation and evaporation of the ſuperfluous moiſture, it became more and more indurated and exſiccated; that by this means, the earth, in particular the firm rock, came, by violent ſhocks, or earthquakes, to acquire rents and fiſſures; that in theſe, the ſeveral ſorts of waters happened to lodge; that theſe waters contain earth; this earth turns to tranſparent ſtone; all which propoſitions are eaſily deducible from what has been already ſaid: at leaſt, no one, rightly conſidering the proper crude ground-bed of theſe *druſy* ſtones, can find any better method of accounting for their origin: that they ſhould ſpring up from it like a muſhroom, the bare inſpection is ſufficient to diſprove; as no coheſion or connection appears between them, only an external application; and this ſo very evidently, that the *druſy* ſtone lies quite looſe and naked in its neſt or bed, conſequently, without manifeſting any thing like a root, or with its ſtem, which is moſtly a quartz or flint adhering to it, eaſily ſeparable from the crude rock underneath, in which no root is obſerved to run and loſe itſelf: neither can theſe unſaline cryſtals be ſuppoſed to proceed from pure damps or *weatherings*, for the weatherings that produce any thing in fiſſures, move laterally, as may be ſeen in ores on *druſe*; whereas the ſtones in queſtion ſtand up and down, like a ſet of teeth in a jaw-bone; nay,

nay, ſometimes with pieces in them like *water-nuts*, which ſcarce cohere in one ſingle point, often not at all. Upon the whole, all circumſtances agree, that neither an *exhalation* nor *inhalation*, but a cryſtalliſation from waters, like the ſhooting of ſalts or ſugar, is the genuine, if not the only cauſe of mountain-cryſtals, and the like tranſparent, variagated ſtones. I ſhall ſay nothing of their figures, which, like common ſalt, are either cubical; or like nitre, priſmatical; or like *tartarus vitriolatus*, of irregular angles, and unequal ſides, commonly hexagonal: nor mention, that an unſaline cryſtal earth, tho' not in ſuch plenty as a ſaline, is yet as intimately mixed in the water, nay, in the fulleſt degree of clearneſs, paſſes through the cloſeſt ſtrainers; conſequently, the cryſtalliſaſation of ſalt is here not improperly alledged for a model, or pattern. In ſhort, the *pyrites* is a thing that has grown, ſtill grows at this day, and will continue to grow on *druſe*, ſo long as the interior parts of this maſs of earth are ſubject to thoſe motions and diſſolutions they hitherto have undergone. Here 'tis worth remarking, that the *pyrites* generally poſſeſs the eminences of the *druſe*, and often their outmoſt tacks or teeth, and that only with one of their angles touching in the feweſt points poſſible, and not lying, but ſtanding thereon; ſhewing that they were not there produced, but conveyed thither from ſome other quarter.

I have had many ſamples of *mixt-work*, with rents and breaks in the rock; the former filled up with, and the latter joined together again by *pyrites*. Some *druſe*, or quartz, manifeſt ſuch cracks and apertures, as plainly ſhew they were formerly entire, and afterwards burſt or ſprung aſunder; and in theſe fiſſures the *pyrites* has been found *inweathered*, or lodged: ſo that I know not whether

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it be ſo very neceſſary to trace ſuch fiſſures as high as the creation, and not rather ſuppoſe them of a much later date. Moreover, I have had pieces very clearly ſhewing that they were broke off, and again joined together by a *pyrites-weathering*, or damp, forming one entire maſs; nay, in part, cruſted over with *pyrites*; but this cannot be reckoned any thing new, or uncommon.

What is worth enquiry is, how *pyrites* can get into cloſe ſolid rock, as a *knauer*; as miners, after maſons and quarry-men, call a ſort of quarry-ſtone, found with us, and generally elſewhere, directly beneath the under-turf earth; conſiſting of very ſmall, nay, ſcarce diſtinguiſhable ſeams, and two ſorts of ſtone; one, a grey, ſparkling, ſcaly ſort, or a *glimmer*; the other, a white, quartzy ſort, conſtantly interchanged with the former, and both cloſely joined together.

In this *knauer* ſmall eyes of *pyrites* lie, and that on the fineſt fiſſures, but not diſcoverable before the ſtone is parted aſunder, and then moſt certainly, the *pyrites* often appearing ruſty; conſequently, a *weathering*, or a *watering* producible of ruſt, muſt have found acceſs thither. Theſe eyes are alſo here and there ſingly interſperſed in the moſt entire and firm rock, without the leaſt ſigns of any deſtruction or diſſolution. Whether the firſt be ſhoots or capillary veins from larger branches, I ſhall not pretend to determine, but the ſecond are ſomething peculiar: they cannot be conſidered as ſmall *ſhoads*, as the *knauer* itſelf is not ſuch, but a rocky, wild ſtone, conſtituting an original part of the creation; conſequently, ſuch eyes muſt have been produced in its ſoft, juicy, and yielding ſtate, before the matrix was become perfectly hard, and unfitted for conception, in which caſe, the impregnating damps and mineral juices could have no acceſs.

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We are next to examine thoſe periwinkle and muſcle ſhells, either quite penetrated, or cruſted over by the *pyrites*; and ſome of theſe ſhells have their whole cavity lined therewith, as the *belemnites*; others, together with the *pyrites*, hold a ſelenitical matter, or gypſum-ſtone; again, in others, the ſhell is entirely *pyrites*; again, the *pyrites* is externally *weathered* on the periwinkle or muſcle figure, which is commonly a marl, or gypſum-ſtone, ſometimes at one, ſometimes at the other end, and ſometimes all over it; and, which is the rareſt caſe, the ſhell ſtill remaining, the *pyrites* lies immediately either on, under, or between the ſhell. Now though periwinkles and muſcles are in ſuch quantities in nature, the number thus petrified is hitherto found inconſiderable; but the ſamples I have either in my own poſſeſſion, or have ſeen, or been told of, are moſtly *cornua ammonis*, *tellinæ*, *chamæ*, *aſtroitæ*, *belemnitæ*, *turbines*, *pectinitæ*, *fungitæ*, *alveolus*, *Luidii*, &c. Though 'tis not to be doubted, but time may diſcover more ſorts; nay, that the ſame may be preſumed of all ſuch as lie in earths, where nature finds materials, opportunity, juices, free acceſs, and the like circumſtances, as grounds and foundations for a *pyritification*; for, both muſcle and periwinkle *works* are all, in the ground of their earthy mixtion, one and the ſame, namely, already ſuch in nature as that, among all the parts of animals, nothing comes nearer to the ſtones of the mineral kingdom, eſpecially the calcarious ſort; conſequently that they are fitted, almoſt in their native ſtate, or at leaſt without any peculiar tedious preparation, barely by means of a ſlender exſiccation, both for a proper petrification, and the conception of ore, is not repugnant to my hypotheſis. And thus it depends on the abovementioned circumſtances, that ſuch ſhells are, at ſome times, now found changed;

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at others, not at all; alſo, that the ſhells either continue to ſubſiſt, or are entirely conſumed; and laſtly, that generally they have no *pyrites* in or about them: as, among others, we have an inſtance in the ſand-ſtone, wherein I have, with difficulty, found ſuch *pyritified*. From a due conſideration of all the circumſtances evident in this ſubterraneous muſcle hiſtory, we cannot ſuppoſe theſe bodies to be the effects of a *luſus naturæ*, or even to be of a ſubterraneous origination.

And ſhould it be objected to my making the productions, namely, the volatile ſalts and fœtid oils, procurable in the fire from ſuch foſſil, figured wood, muſcles, and bones, certain indications of their vegetable and animal original, that theſe ſalts and oils are already contained in the earth, in particular, that common ſalt is extremely fitted for volatilization; that, probably, the ſal-ammoniac at Puzzuolo in Italy, and the like places, where the bituminous ſea-water, or even ſal-gem, is, together with *pyrites* and ſtone-coal, made to act in a due manner in the bowels of vulcano's; and the petrols, which ſtand proximately allied to amber and ſtone-coal, greatly reſemble our oils, burnt out of the fatty, reſinous parts of plants; that from *aſphaltum*, black and yellow amber, from aluminous, ſtone-coaly, black, fatty, ſhivery minerals, not only ſuch oils, but, in part, alſo volatile ſalts may be prepared; yet it does not therefore follow, that the origin of theſe things in queſtion, though they manifeſt themſelves in, is immediately from the mineral kingdom. In a mediate ſenſe indeed, according to which every thing in nature is in a conſtant rotation and flux, we muſt allow, not theſe matters only, but alſo the entire vegetable and animal kingdoms, to be derived from the earth, and thence from the widely extended mineral kingdom.

Now,

Now in and upon these matters, dug out of the earth, all kinds of *pyrites* are often very evidently seen; tho' not so frequently on bones, at least so far as my experience reaches; a thing not to be wondered at, seeing they are not so common as periwinkle and muscle shells are; the same also holds good of wood, which is not so well adapted for mineralisation. To conclude the business of the generation of the *pyrites*, and of ores in general; they are not all of them to be ascribed to the first day of the creation; consequently, nothing hinders their being still produced at this day.

I have still to add, that the generation of ores appears in some measure to me in the same light, as that of vegetables and animals. In some measure, I say: For (1.) ores shed no formal seeds, from which, with the concurrence of a proper matrix, ore is again produced. (2.) Ores, according to their internal mixtion, have no fixed period of duration, but remain for ever unchanged, if not exposed to external violence, partly, on account of their peculiar unchangeable manner of mixtion; partly, their bedding, from which the air and warmth those grand instruments of destruction are excluded. Whereas vegetables and animals have their destined periods, tho' stretched out ever so long, from the tenderness of their mixtion and texture; but so far only I make the resemblance to hold, as in the vegetable and mineral kingdoms, some die, and others again revive.

CHAP.

CHAP. VI.

Of the IRON in the PYRITES.

IN the foregoing chapter having treated not ſo much of the material origination, as rather, if not principally, of the time of the production, and conſequently of the creation and generation of the *pyrites*, I ſhould now immediately proceed to its material principles: but this, at preſent, is neither adviſeable nor poſſible, tho' a method of writing that moſt are fond of: ſeeing we muſt firſt conſider *pyrites*, as analyſed into its proximate parts, and thus mediately proceed to its principles: and we can as little pretend to begin our reſearch as deſcription there, where nature has begun her work; there being difficulty enough to diſcover ſuch principles, as I will not ſay, ought to be made objects of our ſenſes, a thing neither poſſible nor reaſonable to acquire, but by probable concluſions only, fairly flowing from obſervations.

There is the ſame difference between the conſtituent parts and the original principles of a natural body, as between proximate and remote; *pyritæ* are derived from water and earth, as their principles, or remote parts; but conſiſt of the following *mixts*; viz. the fat earth, or ſulphur; the mercurial earth, or arſenic; the metallic earth, or *iron*, as their proximate parts. Some inſtances there are, in which *analyſis* ſtands verified by *Syntheſis*; others, in which it does not. Cinnabar not only conſiſts of quickſilver, as its ſeparation plainly ſhews, but may again be formed from

ſulphur and quickſilver, and that moſt eaſily and conſtantly; and there may ſpeedily, though not conſtantly, be prepared a formal antimony from regulus and ſulphur: But in compounding ſulphur and iron, the parts into which a pure *iron-pyrites* is evidently reſoluble, it does not ſucceed. The reaſon of this difference is, in the firſt place, to be ſought for in the metallic earth of *iron*, which is highly coarſe and fixed, nay the crudeſt of all, and proximately derived from the univerſal unprepared earth itſelf, and conſequently not ſo combinable with the tender, volatile, elaborated, mercurial, reguline earths. 2dly, The ſulphur, which is ſomething highly tender, volatile, and diſſipable, flies off and is deſtroyed, before ever the *iron* can, by ignition, be brought to conception; or the *iron* comes to be unfit for the purpoſe, by loſing its metallic form, and turning to a ruſt, in which the ſulphur cannot find a due ingreſs to coaleſce with it. And hence it is, the ſulphur is ſo ſuperficially combined with the *iron* in the pure *iron-pyrites*, that without any force or violence, ſuch as cinnabar and antimony require to ſeparate out of it, barely by the external heat, nay, by the bare acceſs of the air, without fire at all, it may be made to operate on its accompanying *iron*: which is the formal reaſon of the crumbling and vitrioliſation of the *pyrites*. It, however, from hence and other inſtances appears, that the rule, implying the neceſſity of proving *analyſis* by *ſyntheſis*, among ores and decompounds, ſuch as ores commonly are, ought not to be looked upon as univerſal; ſome bodies evidently bearing *analyſis*, but with difficulty, if at all, *ſyntheſis*; for inſtance, the *pyrites*; others again eaſily bearing compoſition, but difficultly, or not at all, reſolution; as the neutral ſalts.

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We ſhall, in the firſt place, enquire into the conſtituent parts, then into the principles of the *pyrites:* the former we ſhall conſider in this and the following chapters; the latter, namely the principles, in a chapter apart.

In order to treat with propriety of the conſtituent parts of the *pyrites*, we muſt premiſe its diviſion into *ſulphur* and *arſenic-pyrites*. By the former I underſtand not only that ſort which yields ſulphur and pure *iron*, with little or no copper or arſenic, conſequently little or no ſandarach: but alſo *copper-pyrites*, nay, rich copper-ores; by the latter, that white ſort, which contains pure arſenic with but very little *iron*, copper, or other metal, and with little or no ſulphur; the arſenic being in form either of a grey meal, or a ſooty arſenical ſublimate or *fly-ſtone*, and giving, by means of a proper addition of ſulphur, ſandarach; this kind of *pyrites* is at Friberg called *miſspickel*, but in the Obergeburge, *poiſon-pyrites*.

In ſhort, the former are either more, or entirely ſulphureous; the latter more or entirely arſenical. Now in the ſulphureous, the *iron* is the principal and largeſt part, and of which they all indeed conſiſt; copper holds the ſecond rank, which in ſome is none at all, in others in a ſmall, in others again in a very rich proportion; ſulphur, the third, and which like the *iron*, is in all the kinds of the *pyrites*; arſenic, the fourth, of which in many there is none, in ſome only a very ſmall proportion, in others a conſiderable one, bewraying itſelf either in the *ſulphur-ſlags*, or in the ſandarach; but contained in no one *pyrites*, where *iron* and ſulphur conſtitute the capital parts, ſo largely, as without the addition of *miſspickel* to the

H 2 *ſulphur-*

sulphur-slags, to be worked for sandarach, so as to quit the trouble. In the arsenical sort, a stoney *iron-earth* is the principal and largest portion; and what is called the *fly-stone*, the second and last; with the observation, that whereas the sulphur in the first sort makes a fourth in respect of the *iron*; here at Friberg the arsenic in the *misspickel* commonly makes a third; and at the Obergeburge, often a full half, in respect of the remaining irony, quartzy matter. Nay, the abovementioned black, arsenical, fossile matter, otherwise to be found near *red-goldish* ore, but particularly pure, without the like accompanying rich silver-vein, in a mine near Schwartzenberg, and there also called *poison-pyrites*, also *testaceous cobald*, contains neither *iron*, nor any other earth, but in the fire sublimes in its entire substance, and thus proves a pure arsenic, or fossile *fly-stone*. But here the name is misapplied, if we abide by the definition of *pyrites*, namely, its being an ore, consisting either in a sulphurated or arsenicated metallic earth; whereas this, on the contrary, can shew nothing, either of a metallic, or other earth. On these several constituent parts of the *pyrites*, I shall take notice of what I take to be subservient to my principal view.

To begin with *iron*, as the principal constituent part of the *pyrites*. In general, it deserves to be remarked of that metal, that it consists of a metallic earth, proximately arising, above all others, from the crude, undetermined earth itself; as, among other things, appears from the following observations. (1.) In moisture, particularly in the moist earth, it very easily turns to a rust, consequently to an earth; which can be said of no other metal, but lead and copper, which change, the one

one to cerufs, the other to verdigreafe, tho' neither fo quickly, nor in fuch quantities. Nay, fuch an earth, efpecially that from *iron-ore*, fhall, according to Becher's peculiar experience, fo very much degenerate, and turn to a mud and loam, as to lofe all metalleity *. (2.) *Iron* alfo, by fire, turns fooner to a ruft and earth, than copper, lead, tin, and quickfilver, which fubfift longer: and this rufty *iron-earth*, particularly that procured by means of the air or water, and which, in various views, is now called *finter*, now *ochre*, now *yellow*, fo nearly refembles, in tendernefs and fattinefs, an univerfal, yellow-brown, marl-earth, as to be undiftinguifhable from it. (3.) Amongft ores, iron in the *pyrites*, next to cinnabar and antimony, holds the moft fulphur, but parts with it much eafier than they, even fpontaneoufly; and though in the *mercurification* and *regulation* of cinnabar and antimony, it muft feparate the fulphur, yet it takes a little to itfelf. Copper retains fulphur more obftinately, fluxing and caking together, rather than parting afunder. The lead in *lead-glitter*, or galena, will neither fo eafily feparate from its fulphur, but rather vitrify into a cake; though here, as for antimony, *iron* is ufed with advantage, for parting the filver: regulus and quickfilver go forth with the fulphur, rather than part with one another. In a word, *iron* has too coarfe, and fulphur too fubtile an earth, to be able, though ftrongly operating on each other, to mix and combine together laftngly. (4.) *Iron*, by cementation, takes a much lefs quantity of fulphur than copper does; for, equal parts of fulphur being conveyed on glowing *iron*, and glowing copper, the former comes to have about an eighth, the latter a full third part combined to it. (5.) *Iron*, as well as fome other metals, refufes to amalgamate with

* Phyf. Subterr. p 595.

quickſilver; a circumſtance to be aſcribed to its earthineſs, as to a crude, unprepared metalleity. In the next degree to iron ſtands copper, which alſo reſiſts quickſilver, as we ſhall afterwards perceive. (6.) *Iron* is a metal generable not only from all ſorts of crude, particularly loamy, claiey, marly, fatty earths, as Becher's famous experiment ſhews, but alſo gives itſelf forth, both by nature and art, from vegetable and animal earths, and thus from earths already derived from the mineral kingdom; as *there*, M. Lemery ſhews *, by the magnet, from wood reduced to aſhes; M. Seipius †, from a piece of wood found reduced to *iron* in a certain ſpring: and I myſelf, in my ſmall collection, can ſhew from the like peculiar pieces from Bohemia; and M. Liebknecht §, from the like ſamples: and *here*, from the bones of men turned to *iron* ‖. Now I would gladly ſee half theſe obſervations, nay, Becher's ſingle experiment only, as eaſily applicable to other metals. So greatly does *iron* differ from all its ſiſter metals, as to claim the right of primogeniture! Only we muſt guard againſt running into the alchemiſtical conceit of the other metals being derived from *iron*. And here we may, with Stahl **, juſtly complain of Becher's not having diſtinctly enough communicated Paracelſus's experiment on the tranſmutation of *iron* into lead.

Now, ſince a crude, loamy, and ſlimy earth may ſo eaſily become metallic, particularly *irony*, 'tis no wonder we ſhould look for an *iron ore* in claiey, luty, ſhivery, talcky, loamy, &c. beds: and

* Hiſt. de l'acad, &c. Can. 1706
† Vom Pyrmonter Sauer brunen. p. 51.
§ De ligni in mineram ferri facta metamorphoſi.
‖ Acta Erudit. An. 1682.
** Spec. Bech. p. 159.

and ſince the *pyrites* is there ſo often to be met with; beſides, no other mineral ſo very common and plentiful in all ſorts of ſtone and earth; and *iron*, ſo univerſally preſent in all *pyrites*, nay, in many other ores, 'tis more ſtill to be wondered that the ancients ſhould have overlooked it ſo much, and turned their thoughts on copper only, to the quite diſregarding the iron-yield of the *pyrites*; in which reſpect Agricola himſelf ſeems alſo to be at a loſs. And, ſo far as I can learn, Dr. Martin Liſter *, was the firſt, or among the firſt, who ſeems to be aware of *iron* being the capital conſtituent part of the *pyrites*, or the firſt who clearly expreſſed himſelf in this matter: Pyrites *purus putus ferri metallum eſt*, the pyrites *conſiſts entirely of* iron; though (when in another place he ſays, *unus Angliæ* pyrites, *purum putum metallum eſt*, *one ſort of* pyrites *conſiſts entirely of iron*) I much doubt, whether he was quite ſo ſure of the truth of his former enunciation, and whether he knew to give it its full latitude, and true extent. Among the Germans, together with the celebrated Dr. Hoffman at Hall, the famous Dr. Berger claims the honour of the diſcovery, as he has ſolidly ſhewn in his excellent treatiſe on the Carlſtad baths †. As to myſelf, I had ſome difficulty, at firſt, to admit of the vaſt extent and ſpread aſſigned the *iron* in all ſorts of *pyrites*; nor were my doubts removed by conſulting either ſmelters, or the writers on natural hiſtory, but by a careful examination of the ſeveral ſorts of *pyritæ* themſelves, and that with no ſmall pains and expence; by that means only I came to be fully convinced of the truth of what Liſter and Berger had writ to that purpoſe. What made me call in queſtion the aſſertion of theſe great men was,

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* De Fontibus Medicatis Angliæ, p. 43. Ib. p. 19.

† Bergeri Commentatio de thermis Carolinis.

that thoſe *pyrites*, which, with us at Friberg, give only a few pounds of copper, are no longer called *pyrites* abſolutely, but *copper-pyrites*; and that thoſe containing ten, twenty, thirty, and more pounds of that metal the quintal, ceaſe to be called *pyrites*, and take the appellation of *copper-ores*; that, however, many, nay, moſt *pyrites*, with us at Friberg, are not purely martial, having ſome ſmall matter of copper in them: but, in fact, I ſoon diſcovered the above aſſertion to have all the juſtneſs and ſolidity that any other propoſition in mineralogy could poſſibly claim: and my experience in *pyrites* has been ſo extenſive, that, without heſitation or reſerve, I may aver, all the ſorts of them, the *white*, the *yellowiſh* and *yellow*, in regard of metal-yield, to conſiſt either entirely of, or to hold *iron* in equal quantity; or ſhould the *iron* be exceeded by the copper, yet ſtill to maintain its rank as a conſtituent part thereof.

Therefore I aſſert more than what, I think, the above authors have done, namely, that *iron* conſtitutes the ground-earth of all ſorts of *pyrites*; a truth to be met with in no other author that I am acquainted with, though no great art be requiſite for making the diſcovery, being what is eaſily found by only the magnet; a circumſtance that ſeems to do no great honour to our care and attention, as thus the moſt common and obvious things often eſcape our knowledge; not to mention the ſubtilities and empty ſpeculations of philoſophers, who, overlooking the information of the ſenſes, rather confound than clear up matters.

The Heſſian *pyrites* from Almerode, called *terra martis Haſſiaca*, and *Solaris*, but from what heaven

ven I know not; the round *pyrites* of Alt-ſattel, not far from Egra in Bohemia; the *pyrites* from the Schloſsberg of Toplitz; alſo that round *pyrites*, eaſily crumbling or falling to pieces in the air; and the *periwinkle* and *muſcle pyrites*, are, all of them, a pure *iron-pyrites*, without any the leaſt copper; alſo excel all others in the fineneſs and purity of their ſulphur. In a word, the *pyrites* of Acidulæ, Thermæ, and other medicinal ſprings, nay, all *pyritæ* in general, that ever came to my hands, and were ever found at mines, in fiſſures and veins; or that only *break* in clay, loam, ſand, ſhiver, lime, and other ſtone-quarries, are, with reſpect to the metal, almoſt all pure iron, only that they are often intermixed with a little copper. In Miſnia there is neither mine, nor vein, of what kind ſoever, coarſe or noble, at what depth ſoever, in what direction or point ſoever of the compaſs; no ore or ſtone, of what nature or name ſoever, where the *pyrites* does not moſtly and principally conſiſt of *iron*, the copper adhering to it being ſcarce viſible, much leſs educible. All the copper-ores of the following Miſnian mines, *viz.* the Halſebrucke, Kuhſchaft, Hohenbircke, Kroner, Braunſdorff, Kayſer-Henrich, Zwolf Schluſſeln, &c. are never without copper and *iron*; nay, often contain more of the latter than of the former.

One proof of this propoſition, namely, that *iron* is the ground-earth of all ſorts of *pyrites* the magnet ſupplies us with, and ſo much the more infallible, is this proof, as we know of no other body thus acted on by the magnet; though its force may be ſpoiled, or impeded, upon over-burning, eſpecially in an open fire, and reducing the *pyrites* to a brown-red, ruſty earth: but this earth may again

again be made to anſwer the magnet, if, by a due ſmelting, its metallic fattineſs be again procured to it. All *pyrites*, without exception, deſulphurated in cloſe veſſels, anſwer the magnet equally with ſmelted iron, and a genuine *iron-ſtone*. Even the *pyrites*, that contains copper in no great quantity, is acted on by the magnet; that holding much as ten, twenty, thirty, and more pounds the quintal, not ſo ſtrongly, but more or leſs in proportion to the copper it holds; but the copper predominating in a greater proportion, the virtue of the magnet proves more weak and effete, or has no effect at all. The magnet alſo exerts ſome efficacy on the *miſſpickel* of Friberg, and the *poiſon-pyrites* of the Obergeburge.

In order to know what ſort, and how much of other metals the magnet can bear, ſo as to continue to exert its virtue; I, by it, after deſulphuration, examined different *pyrites-copper-ores*, and plainly found it attracted them all, though not within the ſame ſphere, nor with the ſame briſkneſs of activity, as it does the pure *iron*, or poor copper *pyrites*; but by it I could not diſcover the exact proportion of *iron* and copper in each, and, conſequently, how much copper the magnet can bear in the *iron*, without loſing its virtue thereon; only I obſerved a greater efficacy exerted on one ſort, as the *pyrites* of Ilmenau and Sweden, than on thoſe from Lorentz-vein, near the Halſebrucke; thoſe from the Kuhſchaft, Kroner, Kayſer Henrich, Goſlar, &c. in general; but then 'tis not poſſible, in an intelligible manner, to ſpecify the particular degree of attraction. Again, I am not ſure, whether the *pyritæ*, which here, in reſpect of the magnetic virtue, are to be compared together, have always gone through one and the ſame degree

degree of fire. For, according as a copper-ore happens to be burnt too little, or too much, the magnet manifests a greater or less degree of briskness on it: and should I attempt the making a proof or two only, it would be impossible so exactly, in the other proofs, to hit again on the due length of time, and the proper degree of fire: or, should I work several proofs at once, as, for that end I have constructed my reverberating furnace for desulphuration, one and the same degree of fire could not possibly be applied to each apart: not to mention, that of many ores I have only employed small parcels, being only provided with such; whence 'tis easy to judge, a small parcel may be sooner fitted for the magnet than a larger: and lastly, 'tis probable, *pyrites-copper-ores* do, together with the two capital metallic earths, contain also a crude, unmetallic earth, and that in various proportion, and which is neither to be weighed nor measured. So that, besides the copper, there is something else in the *pyrites*, that hinders and weakens the effects of the magnet.

But, still more certainly to discover the proportion of copper the magnet can bear in the *iron*, I melted both these metals together in different proportions; as for instance, filed *iron*, and filed copper, in various layers, committed to a crucible, with a flux consisting of two parts of the black flux, and glass, and one of borax and salt of tartar, to between one and ½ and two parts of metal, and found the magnet could bear in the *iron* half the copper; nay, I doubt not, a greater proportion, which I cannot at present ascertain, as several proofs miscarried with me. Being engaged in these experiments, I was willing to know what, and how much of other metals the magnet could suffer in *iron*, and the result was as follows.

(1.) *Iron*

(1.) *Iron* dosed with the above salt and glass, even in the briskest fire of a wind-furnace, not to be brought to flux without calcination and reduction. (2.) *Iron* making a black slag. (3.) *Iron* refusing melting with lead, and always swimming a-top, unless previously divested of its metalleity, and reduced to an earth; whereas, otherwise, in its metallic form, intimately entering into all metals and semi-metals. (4.) *Iron* burning away sooner than copper, because more difficultly smelting. (5.) *Iron*, to be acted on by the magnet, bearing as much gold as copper. (6.) Also as much silver. (7.) *Iron* entering tin, forming therewith a regulus, on which the magnet strongly acts. (8.) With zink forming a malleable regulus, like silver, yet hard, and not backward to the magnet. (9.) *Iron* going into bismuth in such sort, that tho' the brittle regulus thence arising, be considerably impregnated with, nay, consist of above ¾ bismuth, yet, notwithstanding, answering the magnet. (10.) *Iron* melted along with brass, continuing still subject to the magnetic virtue, where the calamy is still observable from the yellow cast of such *iron*. (11.) The magnet also bearing regulus of arsenic, prepared by means of *iron*. (12.) Bearing *fly-stone*, sublimed from *misspickel*, or poison-*pyrites*; also the being smelted with *iron*. (13.) But not at all bearing the regulus of antimony in the *iron*, though I have made the trial in various ways; neither the *lapis de tribus*, though metallising with *iron*; a circumstance I as much admire, as others may be apt to disbelieve it. I shall further add, from my experience, that from *iron* and tin, a quintal of each, I have procured one quintal and ½ of regulus; from four quintals of bismuth, and one of *iron*, four quintals and ¼ of regulus; from

—— quint-

—— quintals of *iron* and antimony; four quintals of martial regulus of antimony.

A ſecond proof for the univerſality of *iron* in *pyrites*, we have from antimony, ſeeing on the *pyrites* the ſulphur of the antimony is equally conſumed, as on forged *iron*; depoſiting, eſpecially with the addition of proper ſalts, the regulus, ſo far forth as the pulverized ſtate, to which the *pyrites-iron* muſt, by the deſulphuration, be reduced, will permit: ſo that the very few *pyritæ*, wherein the copper entirely predominates, cannot reaſonably be ſuppoſed to affect our proof, as the exiſtence of ſuch an *iron* metal-earth ſeldom can be denied.

A third proof we have from the vitrioliſation of *pyrites*; all *pyrites* giving forth a vitriol, as they all hold a ſulphur, excepting the *miſspickel*, when pure and unmixed with other *pyrites*. All ſorts of vitriol, whether native or factitious, are either purely martial, purely coppery, or conſiſting of both: the firſt is of a ſea-green caſt, and ſweetiſh taſte; the ſecond blue, and taſting ſharp and nauſeous; the third, wherein the martial predominates, may conceal its coppery nauſeous admixture from the ſight, though not from the taſte. In ſhort, all vitriols conſiſt (1.) of the ſtrongeſt mineral acid, which comes either from ſulphur, or the air: (2.) of a metallic earth, which is always either *iron* or *copper*, or both together, though in different proportions; whence all the vitriols, as they are called, from ſilver, lead, &c. made by means of aqua fortis, vinegar, &c. cannot be claſſed with the abovementioned. As to pure coppery vitriol, it will be a hard matter to find any ſuch; for though the *cement waters*, as they are called, or, properly, the *copper-waters* of Hungary,

gary, and other parts, do, by throwing in *iron*, let fall the fineſt ſort of copper, it does not follow that they are purely coppery, ſeeing there are few pure *copper-pyrites* in nature: and ſuch *pyrites* as naturally turn to vitriol, cannot do ſo without ſome admixture of iron; but a pure copper-vitriol muſt be ſolely prepared from fine, ſmelted copper; or otherwiſe, by art, and with the greateſt attention ſeparated from mixt vitriol. The third ſort is the moſt common and univerſal at mines and huts; and, whether native or factitious, it will, upon proper trial, particularly upon a due ſeparation, be found to be mixed. The firſt ſort is, nevertheleſs, not ſo very rare, that we need go in queſt of it as far as Almerode in Heſſe. But tho' our ſulphur and vitriol *pyrites*, as they are called, generally contain ſome copper, yet, by a due evaporation, and cryſtalliſation, of ſuch vitriolic admixture, a conſiderable quantity of pure *iron* vitriol may be procured.

(4.) It is alſo obſervable, that the regulus procured in ſmelting for copper-ores, and called *black copper*, has that black colour chiefly, if not always, from the *iron* ſuch ores happen to contain: moreover, there is no one ſort of copper-ore, that remains untouched by the magnet.

(5.) I might here alſo alledge thoſe ſcoriæ, which, in copper-ore proofs for ſilver, always ariſe dark and black; whereas, doubtleſs, had there been no *iron*, the colour would prove of a liver, a brown-red, even to a high-red caſt, the proper colour of copper: for though lead, without which no *incoction*, or *ſcorification*, can poſſibly be made, ſhould happen to mix with it, yet it could not entirely deſtroy the original colour of the copper; as

as little as it does the black caſt of the ſcoriæ of *iron-pyrites*, though it bring them ſomewhat nearer to a brown. I ſhall leave to further reflection the vitrification I performed, without *additions*, in a glaſs furnace; where, both from copper-ore, the common *pyrites*, pure *ſulphur-pyrites*, and the arſenical, as the *miſpickel*, and mock-lead, I uſually procured a black, dark glaſs.

CHAP. VII.

Of the COPPER in the PYRITES.

NEXT to the iron, the principal metallic earth to be looked for, and met with in the *pyrites*, is *copper*. *Pyrites* is never without iron, often without *copper*, which, next to iron, *pyrites* moſt affects, and which, of all other metals, is the neareſt allied to iron; as may appear from the following remarks. (1.) I own there is no experiment extant to aſcertain the tranſmutation of iron into *copper*, though a great deal has been ſaid to that purpoſe; the error having, at leaſt, ariſen from the vitriolic waters of Hungary, wherein a precipitation, rather than a tranſmutation of *copper* happens by means of iron. As Lohneiſs * mentions the like to happen at the Rammelſberg; and the late M. Heineman, inſpector at Bottendorf, made an ingenious imitation to that purpoſe; and I myſelf, but lately, to my great ſatisfaction, in the tin *ſtock-work* at Altenberg. As to the arſenical *pyrites* of Sweden, from Gothe-gruffwan in Weſtmanland, which, after ſome years expoſure in the air, is ſaid to turn entirely to a *copper*, this proves to be either a miſtake, or a bare hear-ſay, without any foundation †; yet, I imagine that a tranſmutation among imperfect metals, ſuppoſing ſuch a thing poſſible, ſhould ſooneſt of all happen between iron and *copper*. (2.) *Copper*, next to iron, is

* Berg-buch, p 332. Toll. Epiſt. Itin.V. p. 192. Wedel. in Ephim N.C. Dec. I. Ann. VI. VII. 1673, 1676.

† Leopoldi Epiſt. de Itin. Suecico. p. 82.

is the most universal metal in nature, there being scarce a vein, whether of lead, tin, or even of the richer sorts, without it; though there are veins of pure copper-ore, without any admixture. (3.) Along with the sulphur in the *pyrites*, *copper* exhibits much such a mixture as iron does, only that in one the colour is somewhat more yellowish, in the other more pale: and in this resemblance other ores do not equal the *pyrites*, though they may one another: for instance; sulphur with lead, sulphur with regulus, also, by means of art, sulphur with tin, have a considerable resemblance among themselves. (4.) *Copper*, 'tis true, does not emit its sulphur so readily from its ore as iron does, but rather runs, and cakes together; and therefore will not bear any violence of fire, but only should be treated with a soft degree of roasting: and when, by the interposition of quartzy, mock-leady, and the like stubborn sorts of earth, their running together, or caking, is prevented, the sulphur also the more readily separates. (5.) Both of them, in one and the same manner, receive again the sulphur by cementation; only that the *copper* is somewhat more penetrated by it, also retains more of it, and for a longer time. For the rest, both of them, along with sulphur, form a rusty, sooty mass; whereas the white metals, and the semi-metals, usually, by its means, acquire a *glittery*, antimonial, and thus a more *ory* form. (6.) All imperfect metals, without any one *addition*, may be made to burn away, or rather lose their metalleity, and turn to an earth; yet none so easily as *iron* and *copper*. Stahl * supposes this to happen sooner to the latter than to the former, but, in my opinion, equally to both; though, from my proofs, which are difficult to be made

* Specim. Bech. p. 298.

accurately, I cannot support the contrary; only so far I observe, that both metals, if not suddenly committed to a very brisk degree of fire, throw off scales, which hinder the smelting; nor do they recover their metalleity even by the strongest pitch of fire, without *additions*, but turn to a scoria or glass: which remark, in regard to a sudden brisk fire, may be also made, with respect to the other metals, particularly lead and tin. (7.) Iron and *copper* are the only two metals, which change to a proper vitriol, a thing not to be affirmed of any other. Whence (8.) it appears, that these metals are of an equal fitness and texture to receive the mineral acid, whether from sulphur or the air; tho' indeed with some inequality in this receptibility, which is greater in iron than in *copper*; whence the latter appears to be of a closer texture than the former; particularly such a body, as returns not so readily to its universal *terreity*, but is arrived to a more heightened degree of *metalleity*. Nay, (9.) they both lodge well together in a vitriol; and tho' at last by a careful evaporation, like all other saturated salts, they may be considerably separated from each other, yet the *copper* with difficulty parts from the iron, after having once been in contact with it. (10.) Next to iron, *copper* is of all metals the most difficult to flux in the fire. (11.) *Copper* is also the hardest metal: whence, among the ancients, in defect of iron, it was used for making swords and scythes; as in the cabinet at Stockholm a sword of that metal is still to be seen, and the like usually to be met with in ancient graves *. (12.) In both, preferably to the other metals, gold finds a lodgment and an aptitude for generation; yet more so in *copper* than in iron. (13.) *Copper*,

* Elvii & Benzellii Schediasma de re metallica Sueco-Gothorum, p. 14.

Copper, next to iron, amalgamates with mercury with the greatest difficulty; whereas gold and silver amalgamate with ease; also lead, tin, and zink most readily. (14.) The magnet chiefly and in greatest quantity bears *copper* in iron.

Whence, *a priori*, 'tis easy to see, what probability there is for *copper* to lodge along with iron in *pyrites*: and, *a posteriori*, or from examining the *pyrites* itself, what just foundation there is for that probability. But, as *copper* is not common to all the sorts of the *pyrites*, some containing pure iron only; and consequently, as the *pyrites* may subsist without *copper*, so *copper* must not be considered in the same light as iron: namely, as an essential part of the *pyrites*. But in regard the incidental existence of *copper* therein extends so very widely, that (1.) very few *pyrites* are without it; (2.) many *copper pyrites* have a large *copper-yield*; nay, some of them, almost to a half; so, next to iron, this metal deserves our greatest attention. Though I would not dispute the excluding such *copper ores*, as come very high in *yield*, from the class of *pyrites* in general, and the putting them in a peculiar class by themselves; and then considering the *copper* therein, not as something incidental, but as a necessary part of that ore. Only we must not, with the Ancients, run to the other extream; namely, that of neither regarding, nor looking for any other thing in the *pyrites* but *copper*, as if they never contained any iron.

Hence it has happened, that vitriols have no one name assigned them, denoting their iron; being indiscriminately called *chalcanthum*, *chalcitis*, *cuperosa*, or *cuprirosa*, &c. And this has so far prevailed, that not only in Greece and Italy, but even in Germany it-

ſelf, all ſorts of vitriol, even that principally from iron, have to this day no other appellation than that of *copper-water*; the iron being conſidered as ſomething incidental, even by modern mineraliſts.

Copper, however, has a very extenſive ſpread in the *pyrites*; in regard to place, *yield*, and alſo *mightineſs*, as miners uſually ſpeak, with reſpect to the breadth and thickneſs of their veins. As to place, there is ſcarce a mine, without ſome appearance of *copper-ore*. 'Tis found in all ſorts of earth and ſtone; in ſhiver, lime-ſtone, quartz, ſpad, *kneiſs*, and *gemſs*: though it generally appears, that the *pyrites* in clays, lutes, and lime-ſtone, are for the moſt part principally *irony*; and often pure and unmixed; whereas *copper-ores*, either poor or rich, muſt be ſought for in quartzy, ſpathy, ſhivery, and the like ſtone. *Copper-pyrites*, or ore, *breaks* at different depths; in ſome places, in *day veins*, as has been ſaid above, almoſt beneath the under-turf-earth; though rarely, and as may be eaſily imagined, thinly ſown, and not ſo *mighty* as in the *deeps*; in other places, and more frequently, in the *depth*; of which the famous mines at *Fahlun* in Sweden are pregnant inſtances.

Here I have often put the queſtion to myſelf; whether the *pyrites* does, with the depth, decreaſe in iron, and increaſe in *copper* yield; namely, with this view; whether the common *pyrites*, employed in making ſulphur and vitriol, and in the operation of *crude-ſmelting*, and in metal pure iron almoſt decreaſes with the depth; that is, becomes weaker or ſmaller in veins? or whether, like other ore veins, as lead and *copper*, it rather encreaſes? And to mention only the *pyrites-copper-ore*, it is well known, that downwards it ſtill grows *mightier* or larger;

larger; whereas the *pyrites* iron-ore, that runs from above inwards, loses itself more and more, upon the encrease of the former. Whence it may be probably conjectured, that iron and *copper* are, in regard of their proximate metallic ground-earth, if not one and the same, yet greatly resembling each other, and differing only in the degrees and periods of coction, maturation, and exaltation: particularly, that those particles, which, in the *iron-pyrites*, were to be carried no higher than to the form of iron, are, in the *copper-pyrites*, on the contrary, or *copper-ore*, to be raised to a higher and nobler form; that is, to that of *copper*, as what requires a different and a more thorough degree of coction and maturation.

What confirms the conjecture of the iron and *copper pyrites* having the same original (in particular, that the *one* is derived from the *other*) is, that the *copper-pyritæ* seldom begin from the *day*, or beneath the under-turf earth; whereas the *iron-pyritæ* commonly manifest themselves there; nay, where the former happen to appear soon (which nevertheless is rarely observed) the latter do not only equally as soon manifest themselves in huge beds, *stock-works*, *bellies*, and *nests*, but are also gradually accompanied by the former. Yet all this does not fully satisfy the query; the nature of the *deepest*, that is, of the sole or bottom of the mine, as far as it has been sunk, being besides to be considered.

Now, here again we are not to doubt, but that *iron-pyritæ* lodge also at the greatest depth, even in the center of the earth; it being possible, that the same causes, that operate near the surface, should also exist at the greatest depths. Our experience and knowledge are, however, not suffi-

ciently extensive, fully to answer this question, a great deal of attention and caution being requisite in forming a proper judgment on the case.

Now, as to the *copper-yield* in each sort of *pyrites*, whether denominated *copper-pyrites*, or *copper-ores*, I have in various ways attempted to discover it, without leaving concealed the smallest share of *copper*, that happened to be therein. As to those that contain much *copper*, or only a *pound* the quintal, the method of extracting it is a thing well known: if first, according to the common way of assaying, they be brought, in their unroasted state, by means of pounded glass, to *crude-stone*; which *crude-stone*, with the usual dose of *black-flux* in a crucible in a wind-furnace may be reduced to *black-copper*; and this again in the assay-furnace to *rose-copper*; tho' to procure the *copper*, on the score of its being apt to burn away, from extremely poor *copper pyrites*, care and experience are requisite. And, as I have had several sorts of *pyrites* from our mines, from which neither I, nor the most experienced assayer, could extract the least *copper*, I have discovered other ways to answer the purpose. The colour I found to be fallacious; and even extremely pale *copper-ores* to be rich in *copper*, this paleness arising from the defect of sulphur, and the over-dose of arsenic.

These poor *copper-pyrites* I tried both in their crude and roasted state, nay even in their iron-regulus, with vinegar, also spirit of sal-ammoniac; as these are sharp waters, which *copper* readily yields to; but without the *copper* giving forth its green and blue colours, on account of their being entirely defended by the iron: and when any green cast happened to manifest itself, it was owing to a coppery

iron-

iron-regulus, and to *pyrites*, where the *copper* ſhewed itſelf bodily by the common proof, without the trouble of torturing with vinegar, &c. Laſtly, I proceeded with them in the way of a vitrioliſation, both by means of the air and fire, oppoſing ſuch vitriol to a pure martial ſort, made by art from iron by means of oil of vitriol; and thus ſufficiently pure from all *copper*: yet there was no difference of colour obſervable; though upon taſting it, its nauſeouſneſs failed not to manifeſt itſelf. But a vitriol, mixed with ſome alum, though otherwiſe entirely free from iron, as is often the caſe of that from ſhivery and black kneiſs, *pyrites-vein-ſtone*, as is that of *Braunſdorff*, and the Hungarian native vitriol itſelf, cauſes ſuch a degree of nauſeouſneſs on the tongue, as though it were coppery, that it is no eaſy matter to diſtinguiſh them: as I was long unacquainted with this, I could affirm nothing with certainty about it, but was again obliged to have recourſe to iron, which at length extracted the *copper* out of ſuch vitriols and *pyrites*, wherein I never ſuſpected any ſuch thing to be. The method in ſhort is, to diſſolve the vitriol in common water, and put a poliſhed iron wire therein; when the *copper*, though in the leaſt quantity poſſible, not only viſibly colours the iron of a *copper-red*, but alſo cruſts it over with a kind of *copper* ſkin, whilſt the iron in the mean time conſumes away, and partly goes into the vitriol mixture, and partly falls down to the bottom; and this ſo long as there remains the leaſt *copper* therein: ſo that this is the beſt way of purifying a *coppery* iron-vitriol, as ſhall hereafter appear more at large.

After premiſing in general the *yield* of other ores, we ſhall in particular treat of that of *copper*. As to the noble metals, gold and ſilver, their *yield*

in some ores, namely, in the *glassy* and *red-goldish* sort, is considerable, or at least so far constant, as that the former, when pure, and without any rocky admixture, affords always above a half, and commonly about two thirds: the latter also, when pure and fine, usually above a half in silver, and never less. But then we must here regard the proper and essential characters of such ores; as no ore is to be accounted a *glassy* sort, that will not bear the being cut, hammered, *&c.* A *red-goldish* sort may also happen to have some foreign admixture, as appears from its dark cast at *Braunsdorff:* and thus in proportion to such admixture, its *yield* falls short of half. But in most ores, the *yield* in noble metals is so variable, that there is no coming at near so much certainty for these, as for the *glassy* and *red-goldish* ores.

Lead-glitter, or galena, holds sometimes a half, sometimes a whole *loth*, sometimes two, three, ten, and more *loths* of silver; not to mention a sort, that rises to *Marks* * the quintal; among which there *break* noble veins, in particular of *white goldish* ore, tho' often very unobservable. *Copper-ore* also, in regard of its silver-*yield*, greatly rises and falls: and here I have observed, that when it comes to *loths*, it is of a dark-grey cast, and then called *fallow copper-ore*; and when to *marks*, this dark-grey hue remitting somewhat, it comes to be called *fallow ore:* nay, the *white-goldish* ore, which, so far as I could learn, is certainly a *copper-holding* sort, only so far differs from *fallow ore*, that sometimes in silver-*yield* it has risen very high, namely, to ten, twenty, thirty, and more *marks* the quintal, and on the contrary, falls in *copper:* and thus the *white-goldish* ore cannot, like the *red-goldish* sort, properly con-

* A mark in the language of assayers is half a pound.

constitute a class of silver-ores; as being not only highly inconstant in silver-*yield*, but peculiarly *coppery*, which can never be said of any *red-goldish* ore.

As to the imperfect, or rather, ignoble metals, their ores are in more instances found of a constant yield than those of the noble; as in particular, we learn from *lead-glitter*, *white* and *green-lead* ore, *tin-stone*, iron-*pyrites*, and *cinnabar*; *glitter*, or galena, commonly containing two thirds, nay somewhat above, in lead; and hitherto I have found none falling much short of a half. The same we observe, and that with more certainty, of no one ore so much as of the rich tin-stone. *White* and *green lead-ore* hold ordinarily above three fourths in lead, and never under, only allowing for its incredible volatility.

Sulphur-iron-pyrites always yields about three fourths metallic, namely, iron-earth; and allowing for its volatility, neither more nor less than a fourth of sulphur. *Arsenical*, or *poison-pyrites*, which has also constantly an iron-earth for its ground, when pure and fine, has a like *yield*, allowing only for a third, or somewhat over, of *fly-stone*, or arsenic. *Cinnabar-ore* has often somewhat foreign in its *mixtion*; thus not always exhibiting its due, beautiful, red character, but sometimes appearing of a brown-red, more or less, almost like a *brown-red iron-stone*; but when arrived to its true degree of perfection and purity is, like the other, found in its proportion of sulphur and quicksilver, as 1 to 6 or 7. And here it were to be wished, assayers were more careful in noting down the several *yields* of their ores, not omitting at the same time to register any doubts that might arise in the course of the process: as by this means we

we might by degrees arrive to certain axioms, that might be depended on, with respect to the metallic *mixtion* of ores.

Some of the above-mentioned ores, namely, antimony and *lead-glitter*, agree more than a little, both in their measure of sulphur and metal-*mixtion*; also in the kind of their volatile, namely, sulphur portion; nay, almost in the volatility of their metallic or semi-metallic portion; and besides, in the separability of their metal from their sulphur. In particular, that these, before all or most other ores, are in their *mixtion* found of a like proportion of metal and sulphur, as that their metal, at least, ever outweighs the remaining ore-portion, but the contrary never happens. Farther, that accordingly, *tin-stone*, cinnabar, *glassy*, and *red-goldish* ores may be classed amongst the first, of whose metallic *yield* the most solid and constant observations may be made.

Now to return to our *pyrites-copper-ore*; I have not only assayed various sorts thereof, but employed all the care and attention needful on such occasions; as separating, picking, and cleaning; and found their *yield* seldom amounting to half, nay, generally falling short by 3, 2, down to 1 pound; consequently a yield so various, as is not easily to be met with in any other genuine ore; a circumstance that deserves a greater degree of attention than has hitherto been thought proper to bestow upon it; not to repeat what was said of lead, quicksilver, and regulus of antimony, whose proper, pure ores in metallic *yield* never fall so low, nay constantly hold to one and the same degree of weight, without any material difference, allowing for what is lost, from their aptness to volatilise, to be

be burnt away, and to scorify, nay, from inattention and negligence in the operator. The same may with more propriety be said of tin, whose proper, pure ore, called *tin-stone*, also *tin-granates*, constantly give the same, and that a rich *yield*, namely, above a half. This great variety in the *copper-yield* of *pyrites* affording us no certain axioms or truths, puts us upon the necessity of framing so many classes of them, as there are different *yields*; and therefore copper is to be considered as something incidental to *pyrites*.

It were to be wished we had some external signs or characters, whereby to ascertain the different *yields* of the *copper-pyrites*. The density, closeness, and weight of the ores are not always to be depended on. Their structure, which is either *stellate*, *testaceous*, or *run*, or *melted together*, as it were, so far manifests the difference of their internal substance, as to shew that the *stellate pyrites* commonly contains no copper at all, or but very little; those consisting of different coats, to be generally arsenical; in which respect they are here at Friberg called *cobaldish*, nay *cobald* itself; but as to those masses of *pyrites*, which appear melted, or run together, it still remains a difficulty to determine their yield. The colour proves a surer guide in this case; the more yellow and greenish the *pyrites* shews, the richer it proves in *copper*: yet, from the absence of these colours, the absence of *copper* must not be inferred. For though this inference might in most instances hold good, especially in regard to some one particular *mine*-work; for instance, that of Friberg; yet the above-mentioned sample of a certain *copper-ore* considerably white, such as I never once after saw, heard, or read of, might caution us against entirely and solely

ſolely relying on the colour. The ſureſt way therefore of judging of theſe ores, where the ſtructure affords no light, is, together with their colour, to take their weight, denſity, and glittering, ſhining appearance into the account. True it is, the abovementioned *copper-ore*, which yields to the quantity of 40 pounds in the centner, appears very pale, and almoſt like a white *pyrites*; but, on the other hand, from its denſity and cloſeneſs, it muſt be of a more metallic nature, and not barely a white *pyrites* or *miſspickel*, but a body only inveſted with arſenic, and thence ought to be imagined to be more *coppery*. But what judgment then are we to form of the *fallow-ore*, *fallow copper-ore*, *copper-glaſs*, and *copper-laſul?* *Fallow-ore* is a grey ſort, darker than the *white-goldiſh*; containing between 1 and 2 *marks* of ſilver, uſually *breaking*, as we ſee at the *Croner* and the *Halſebruck*, with yellow *copper-ore*. *Fallow-copper-ore* is darker than *fallow-ore*, and therefore expreſsly denominated from *copper*, as containing more of that metal, and much leſs ſilver.

Copper-glaſs is ſtill darker, inclining much to a black, as being highly irony. *Copper-laſul* diſtinguiſhes itſelf by its ſteel-blue colour, though miſuſe has introduced the calling a yellow-greeniſh *copper-ore*, a *copper-laſul*. Among the ancients *copper-glaſs* denoted only a *copper-laſul*. But here to obviate much difficulty, theſe ores, but juſt mentioned, may well be excluded the claſs of *pyrites*, as not properly belonging thereto; though I thought it neceſſary to mention them, as they ſerve to clear up the buſineſs of ore-colours; and, in particular, to find out the marks of *copper-yields*. That the iron in the pure *iron-pyrites* appears not black, or as an iron-ſtone, but yellowiſh, is ſolely owing

owing to the ſulphur; without which there is nothing to be found in the pure *iron-pyrites*, capable of imparting ſuch colour to the iron. That ſuch *iron-pyrites*, whoſe ſulphur is only mixed with ſome arſenic, deviates from a yellow more to a white, is undoubtedly owing to the arſenic. That nothing but the *copper* heightens the yellow colour of the common iron and ſulphur *pyrites*, and makes it run to a greeniſh, is a truth as little to be doubted of. But why a *pyrites-copper-ore*, containing 20 pounds of *copper* in the centner, is not ſo eminently diſtinguiſhable in colour from that which holds only 10; and why it is often a difficult matter to know a very rich from a conſiderably poor ſort, three reaſons ſeem aſſignable: one certainly is, the arſenic, which imparts its high colour to the *copper*, as is well known from the operation of *white-copper-making*, and prevents its coming to that degree of yellowneſs or greeniſhneſs, which *copper*, with ſulphur, is wont to exhibit: and thus ſulphur is more copious, nay, as it were, more indiſpenſably neceſſary in *pyrites-copper-ore* than in *pyrites*-iron-ore; as the *ſandarachy*, or ruddy crude ſulphur, always procurable from the *copper-pyrites-ores*, ſufficiently ſhews.

The ſecond reaſon is the proportion of the ſulphur in reſpect to the remaining principles of the *pyrites*, being what I found pretty uniform and conſtant in the pure *iron-pyrites-ore*; but in the *copper-pyrites ore* not only in general, in a ſmaller, but alſo a more variable quantity.

The third reaſon probably may be derived from a circumſtance, of which I ſhall make ſome mention in the following chapter; namely, an unmetallic, crude, undetermined earth; which, as

as in many other ores, so also is it to be met with in the pyrites; and which, both in respect of quality and quantity, may serve occasionally to heighten, or to lower the colours of ores.

This third, together with either a defect of sulphur, or a plenty of arsenic, may be a concurring cause, why the often mentioned rich *copper-ore* of Hohenstein, has acquired so very pale an appearance, that were it not for its uncommon density and closeness, it might easily be taken for a yellowish *pyrites*, or for what it really is not. In such circumstances, we must be upon our guard in judging of the *pyrites* by their colours, at least we must not suffer ourselves to be misled by the pale; though in such things, where many circumstances must often be considered together, colours afford the greatest light, as was observed above, chap. II.

Lastly, I must add, that in the white *pyrites* there is no copper at all. Now, whether any, or how much *copper*, there may be in *kupffer nickel*, a sort of cobald, of a *copper-red*, and allied to the white *pyrites*, is a thing that must be previously enquired into.

CHAP.

CHAP. VIII.

Of the UNMETALLIC EARTH in the PYRITES.

THAT along with the iron and copper in the *pyrites*, there is, befides, a fixed fort of *earth*, which is neither fulphur nor arfenic, neither iron nor copper; in a word, which neither is itfelf, nor can yield, any metal, is a thing deferving a particular confideration, as being one of the peculiar principles of the *pyrites*. Upon this head we fhall briefly only (intending to leave the further difquifition of the fubject to the more minute examination of others) confider thefe four things; (1.) What we are to underftand by fuch an *unmetallic earth*: (2.) Whether fuch an *earth* is to be obferved in other ores: (3.) Whether fuch can be fhewn actually exifting in *pyrites*: (4.) What its nature and properties are.

As to the firft, or what is to be underftood by the *unmetallic earth*; we muft, firft of all, guard the reader againft a miftake, in which he might be otherwife apt to fall, and caution him, that by no means are we to underftand by it the adhering, interfperfed, quartzy, fpathy matters, and the like earth, rock, or ftone, or any thing that is feparable by the wedge, or diftinguifhable by the naked, or even by the armed, eye; feeing fometimes in ores there lies interfperfed, like a fand, a fmall-grained, either quartzy or felenitical, fort of rock, or ftone, as I have had a fample from the Bannat of Temefwaer, in which an unarmed eye could

could ſcarce diſtinguiſh it. I muſt here alſo obviate a falſe notion, which, notwithſtanding the above hints, ſome might be induced to form to themſelves of what we call *pyrites-kidneys*, and balls; wherein, upon breaking them in pieces, we often obſerve all manner of ſandy, ſtoney, and often ſcarce diſtinguiſhable particles, falſely conſidered as eſſential parts in the mixtion of the *pyrites*. I have lately had one ſuch kidney, above a pound in weight, from the ſalt-pit at Bochnia in Poland, where neither externally, nor for an inch deep within it, was to be found the leaſt trace of of a rocky, or other admixed matter, as an eſſential, conſtituent part of the *pyrites*; but, quite internally, I unexpectedly obſerved ſuch; of which the *pyrity* periwinkle and muſcle ſamples are plain, palpable inſtances. But, by the *unmetallic*, fixed *pyrites-earth*, we are rather to underſtand ſuch *pyrites-particles*, as are intimately introduced into the *pyrites-mixtion*; namely, an earth, both by the volatile and fixed earth of the *pyrites*, ſo ſwallowed up, minerallifed, and incorporated, as to be as little diſtinguiſhable as the other *pyrites-particles*, the ſulphur, arſenic, iron, or copper, either by the naked, or armed eye.

This unmetallic earth, like the other principles of the *pyrites*, is derived, as was ſhewn above, from the generation and production of the *pyrites*; from ore and ſtone-forming juices, conveyed in the manner of damps, or vapours for that purpoſe.

(2.) As to the queſtion, Whether ſuch an *unmetallic-earth* may be found in other ores, I muſt own, it was the *pyrites* gave me the firſt hint of this ſort; as in it I found ſomething which could neither

neither be called sulphur, nor arsenic, nor a metallic earth: and, to confirm this, I examined other ores, and found a like earth in cobald and bismuth ores. Cobald, which is used for making smalt, tolerably resembles the *arsenic-pyrites*, or the white *pyrites*, or *miss. ickel*, both externally and internally; only that this last turns to a very dark glass, whereas the first has its earth changed to a beautiful blue glass. Now as the white, or arsenic *pyrites*, has some iron for its *ground-earth*, which undoubtedly is the cause of the black colour of its glass; and as the tint and colour of glasses commonly bewray something metallic, as appears, not only by *analysis*, but by *synthesis*, as in the making of smalts, or enamels; so all blue mineral colours, whether natural or artificial, as lasul-stone, copper-blue, mountain-blue, blue vitriol, arise only from copper. And lastly, as copper shews itself plainly in that sort of cobald, called *kupfernickel*, it is not improbable, smalt may be produced from an earth, not only, in general, metallic, but, in particular, coppery: but as from cobald, by any method hitherto understood, only a very small quantity of metal, either of copper, or any other mineral, is procurable, that bears any proportion to its earth, we must needs suppose its ground-earth, if not all, yet most of it, to be *unmetallic*, crude, vague, or undetermined; particularly, *crude-earthy*, sandy, and thus easily vitrifiable: but the cobald to be employed, must be no *mixt-work*, but such as is highly pure, and carefully separated from its quartz, which not only externally adheres thereto, but often lies very tenderly and inseparably interspersed or mixed amongst it; otherwise it would yield an over-quantity of *unmetallic earth*. This genuine smalt-earth is generally as one to three, in regard to the volatile, arsenical, portion; the arsenic be-

ing what has penetrated, impregnated, and formed the said earth, so as not to become a bare stone, but an ore, and such a sort, as greatly resembles a metallic, in particular, a grey, coppery, and silvery ore. Bismuth-ore, which is greatly allied, and adheres also to cobald, leaves behind, after roasting, (in which operation it yields a semi-metal, called *bismuth*, or *marcasite*) an earth, or stone, called *bismuth-stone*; this earth, like that from cobald, affords a more beautiful smalt, but no metal, in what manner soever treated.

(3.) With respect to the manner of exhibiting this *unmetallic earth* in the *pyrites*, we shall take notice of each of the three principal sorts of them, beginning with the white, or arsenic *pyrites*; after separating the volatile portion of which, there remains behind, in close vessels, a reguline, semi-metallic body, called *fly-stone*; but in an open fire there sublimes a grey, whitish meal, used for making arsenic, leaving behind it an earthy, or stoney substance, that looks greyish, is very light, and generally amounts to about $\frac{1}{8}$. Now, that in this *earth* there is metal, nay, iron in particular, cannot be denied, forasmuch as it is greatly attracted by the magnet, and, in part, by means of proper additions, may be brought to yield an iron-regulus, nay, an iron-vitriol. But (1.) the iron is in a variable proportion therein, whereas the proportion of the entire fixed earth, with respect to the volatile part, comes pretty near to an equality. I have remarked, that not only one sort of *arsenic-pyrites* earth is more affected by magnetism than another; nevertheless, that it preferably turns to iron, as I have had an instance of a sort from Fahlun in Sweden. (2.) But this *white-pyrites* iron is in a very small quantity, that is, scarce $\frac{1}{10}$, in com-

comparifon of the remaining fixed earth. (3.) This unmartial refidue is by no methods reducible to any other metal; and tho' in the intended metallifation many actual iron particles may be fcorified, or vitrified, as may eafily happen in iron, nay, in copper proofs, with an undue degree of fire, or dofe of *additions*, yet this cannot always be the cafe; and certainly we have reafon to believe, that the glafs, or fcoria, to which the fixed white *pyrites earth* runs, is moftly a crude, *unmetallic earth*. As to the yellowifh, or fulphur *pyrites*, there is, by the magnet, and the ufual *fmelting-proof*, more iron in it than in the white *pyrites*: fo that fome of them amount to 50 or 60 lb. of iron in the centner, or quintal; whilft others, or rather the moft, in particular the fpherical, and thofe the pureft *iron-pyrites*, feldom yield more than between 10 and 12 pounds. And again we fee, that, befides the fulphur part, which is generally about $\frac{1}{4}$, and the metal, which is not $\frac{1}{2}$ of the $\frac{3}{4}$ parts of the fixed earth, including alfo the fcorified iron-earth, the half or above the half, which is neither fulphur, nor metal, muft be a crude earth. Laftly, of the copper, or yellow *pyrites*, we may affirm the fame as of the yellowifh, as being nearly allied to each other.

(4.) What the proper nature of this *unmetallic earth* may be, cannot fo eafily be determined; we muft therefore reft contented with the bare knowledge, that there is, in reality, fuch an earth, tho' incapable of exhibiting it pure and in its unvitrified ftate. I call it a crude earth, becaufe from it, as from an unformed matter, a metal may be produced, if either the matrix prove not barren or untoward, or there be no want of impregnating juices, or of a proper length of time for compleating the maturation and coction.

CHAP. IX.

Of the SULPHUR in the PYRITES.

AFTER having treated of the metallic, as well the martial as venereal, and of the unmetallic earth, and confequently of thofe parts of the *pyrites* which are fixed, we now proceed to confider the others; and firft, the *fulphur*, which is a body peculiar to the mineral kingdom alone, as no one fort of ore is to be found without it; fome partake of it in a larger, others in a fmaller proportion; though it is fcarce, if at all, to be found mixed with tin, bifmuth, and cobald: it mixes indifferently well with arfenic, alfo gold, more readily with filver, and ftill more fo with lead, iron, and copper, but, above all, with quickfilver, and regulus. As to tin, I never yet met with any tin-ore, that fhewed the leaft trace of *fulphur*, but rather a pure *poifon-meal*, or arfenic; though this tin ore be not eafily feparable from *wolfram*, a kind of mock-tin, or an irony tin mineral, which muft therefore have fome *fulphur*. A genuine fmalt-cobald, in this refpect, greatly refembles tin; and from bifmuth-ore, as fuch, to extract any *fulphur*, would be more than a little extraordinary. Arfenic, when contained in the mineral called *poifon-pyrites*, or *miffpickel*, may admit of fome *fulphur*, but fmalt-cobald with none; a circumftance worth remarking.

Further, though regulus of antimony be fo nearly allied to bifmuth, as appears by a variety of experiments,

periments, and tho' the former is entirely impregnated with *sulphur*, yet that the latter should not bewray the least appearance thereof, is something uncommon.

Silver manifests still more of it, not only that incidentally lodged in other *sulphurated* ores, for instance, lead-glitter, copper-ore, and *sulphur-pyrites*, *white-goldish*, *fallow* ores, and *fallow-copper-ores*; but in its own peculiar ores, as the *glassy*, and, in some degree, the *red-goldish* ores.

As to gold, it is not certainly known with us, how far, and how readily *sulphur* lodges in it, as I have not hitherto seen a proper gold-ore; and as it is still a question, whether the spangles of gold, to be met with in veins, are not rather native, that is, only lodged there, and not in an ore-state, or mineralised by means of *sulphur*; yet I would not maintain the impossibility of such a state, nay, rather hold, that, where 'tis reduced to genuine ore, it is so, not by means of arsenic only, though principally, but also of *sulphur*; besides which, there is no third body in the whole compass of the mineral kingdom, so capable of reducing metals to an ore-state.

But be this as it will, *sulphur* is more readily found along with lead, copper, and iron, as appears from lead-ores, copper-*pyrites* and ore, and iron-*pyrites*, yet not so peculiar to these metals, as it is to regulus and quicksilver; seeing iron-ore is sometimes to be found without any distinguishable *sulphur*, such as most iron-stone is, in particular, *glass head*. Copper-ore I have found without *sulphur*, as, a copper-lasul from Lapland; also lead-ore, entirely without any, as appears from the

white and green lead ores; but to find quickſilver-ore and regulus without *ſulphur*, would be a prodigy in nature.

Sulphur is more frequently found with the ignoble, rather than with the nobler metals, in their ore-ſtate, and with it, ſometimes, arſenic is combined in larger or ſmaller quantities; a circumſtance not to be affirmed either of quickſilver, or regulus.

Iron and copper, as well as quickſilver and regulus, greatly affect *ſulphur*, which, when without all other metals, is never without both theſe laſt; and in the former too in ſo large a quantity as in the often mentioned metallic middle ſubſtances, or *electra*. In a word, *ſulphur* reduces iron and copper to an ore-ſtate, and forms them into *pyrites*; yet not always in the ſame manner, or proportion.

As to the white *pyrites*, I, for a long time, doubted whether it contained any *ſulphur*, 'till a perſon, employed in the manufactures of *ſulphur* and ſandarach, would, right or wrong, perſuade me, that a ſandarach might be made from white *pyrites*, without *additions*; whence it follows, that it muſt neceſſarily contain *ſulphur*, without which no ſandarach can be prepared. But to omit mentioning now, that I never could diſcover any by my repeated proofs, I found it to be a bare aſſertion, without any foundation; a thing but too common, both at the mines and huts. I cannot, however, deny to the white *pyrites* (though entirely cloſe as ſteel, pure, and without any obſervably interſperſed *ſulphur-pyrites*) any the leaſt matter of *ſulphur*.

In *copper pyrites*, as that holding but little copper, is thus called at Friberg; and *copper-pyrites-ore*, (by which

which I mean what is there called copper-ore, or the *pyrites* rich in copper) possess *sulphur* in such plenty and proportion, as might almost make it looked upon, not as an incidental, but as an essential, constituent part thereof; and this so constantly, that let a *copper-pyrites-ore* be ever so arsenical, it is never without *sulphur*. And here the following remark may properly be made, namely, that *iron-pyrites*, so far as the *white-pyrites*, on account of its very small portion of iron, may be called such, may sooner exist without *sulphur* than *copper-pyrites*.

In genuine *iron-pyrites*, containing the least, or no copper at all, the *sulphur*, in general, amounts to between ¼ and ⅓ of the whole. To mention only the principal sorts; that from Ehrne-Schlange gives 28 pounds of crude *sulphur* the centner, or quintal; from Pretzschendorff, 30 lb. 24 *loths*; from the Rautencrantz, at Johan-Georgen-Stadt, 30 lb. 24 *l.* from the Halsebrucke, 36 lb. 16 *l.* from Braunsdorff, 25 lb. 16 *l.* from the Schlossberg, at Toplitz, 27 lb. 16 *l.* from Almerode of Hesse, 26 lb. 12 *l.* from Alt-sattel, near Egra in Bohemia, 26 lb. 16 *l.* from Boll, in the territory of Wirtemberg, 26 lb. the *shiver kidneys* of Goslar, 24 lb. the Swedish *pyrites* of Nericia, 25 lb. the *pyrites-kidneys* from the salt-pit at Vilizka, 26 lb. the *pyrites* from the Bannat of Temeswaer, 27 lb. 10 *l.* the *pyrites* from the three Wisemen's Levels at Schemnitz in Hungary, 23 lb.

And here we are to remark, (1.) That in close vessels, as retorts, the above assigned proportions of crude *sulphur* are with difficulty, and commonly scarce to one fourth procurable; but an open fire, such as is that under the muffle, fully forces out what

remains behind, which is doubtless a *sulphur*, as appears from the odour of the exhausted *pyrites-earth*, though not to be retained.

(2) The *pyrites*, that in crude *sulphur-yield* exceeds one third, is to be suspected to partake of arsenic; as is the case of the *Halsebrucke pyrites*, which, in its *sulphureous*, and other volatile portion, amounting to 36 pounds in the center, and consequently above one third is remarkably arsenical, and therefore called *cobald*.

In *pyrites*, impregnated with arsenic, as is commonly the sort where copper lodges along with the ground-earth, it proves a difficult matter to make a calculus of the *sulphur*; such *pyrites* readily caking, and running together in the fire, and the more so, by how much richer it is in copper; the reason, doubtless, is principally owing to the arsenic; for, the *white pyrites*, which abounds in arsenic, does the same; that is, running together, it usually cakes: so that the arsenic to the *sulphur*, in the *copper-pyrites*, or copper-ore, rarely exceeds one fifth or one sixth.

Now, the *sulphur* procured from *pyrites*, particularly from the yellowish, or the sort called *iron* and *sulphur pyrites*, generally manifests a yellowish grey cast, and is occasionally called either *crude sulphur*, because it comes from the first process, and is still unpurified; or *caballine*, or *horse sulphur*, as it is proper enough to be used for diseased cattle. This *crude*, or *horse sulphur* is re-committed to the retort, and once more distilled or fined; whereby it turns out beautifully yellow, pure, and fine, the foreign arsenical matter, called *sulphur-slag*, remaining behind at the bottom of the retort.

I can-

I cannot omit suggesting here something very remarkable; whether to call it a new discovery in mineralogy, particularly in the doctrine of *sulphur*, I know not; which, in short, is this, that in the *crude sulphur*, there is an actual iron-earth contained, which not only is readily acted upon by the magnet, but is also *metalised*.

For if you take the *sulphur-slags*, and burn them in a crucible or pot, you procure a greyish, ashy earth, which the magnet attracts, and which, by proper *additions*, may be reduced to an iron-regulus; and this not only when the *sulphur* is treated in an iron retort, the using which might give suspicion of the acid salt of the *sulphur* having corroded and dissolved some of the iron of the pot, but also in earthen retorts.

We have here besides two remarks more to make: (1.) That the above is a certain truth, which may often clear up an experiment, that may happen to be made with *sulphur slags*, and contribute to attain the knowledge of a natural body; whether the iron it holds, happen to be derived to it in an incidental manner from the vessels, in the course of the purification, or in the first *desulphuration* sublime along therewith from the ground-iron-earth of the *pyrites*.

(2.) The more clearly to disclose my thoughts on this head, I am in general to enquire, whether it would be any absurdity to suppose the tender iron-earth, as it is in the *pyrites*, to be at the same time volatilised in the *desulphuration* of the *pyrites*? The copper-earth is, however, fitted for this volatilisation, as the copper-particles in the *pyrites* adhere

here more closely to the *sulphur* than the iron-particles do. But all that can be hence inferred is, that the copper-particles may be more adapted for volatilisation than the iron-particles are; as it must be allowed, that the grossest earthy metal-particles, as iron and copper, nay all imperfect metals, may barely, by the action of the fire, without any additional assistance, be volatilised.

What may help to remove all difficulties, is the having in our eye the two following important and repeatedly confirmed rules:

(1.) That some matters, when accompanied, or combined with something, even not so essential to the design, usually shew themselves, both *passively* and *actively*, of a very different habitude; either more adapted and active, or more powerful and operative, than when employed separately.

(2.) That metallic earths are in their mineral state of a quite different aptitude, than when brought into a metallic body, and smelted. Silver, as a metallic body, will be readily allowed to remain unvolatilised, but combined with common salt, will prove fugitive. The vitriolic acid is one of the most powerful, penetrative, active things in nature, yet deprived of the inflammable earth it possesses in the *sulphur-mixtion*, it can never produce the same effects that it does, when treated in the form of *sulphur:* and the effects of sulphur itself upon metallic earths are owing to its combined state in the mineral of *sulphur*, namely, the *pyrites*.

The grounds of these two practical rules depend sometimes barely on giving a steadiness and body to

to the matters under treatment, that they may not go off too soon in the fire, but have time either to work or to be worked upon; as we see from the production of *sulphur*, where the alkali is only given as a body to the vitriolic acid; sometimes on intimately mixing different things together, though in themselves improper for the intended process; when new combinations, qualities, and effects, must needs be produced.

Now, to apply all this to the volatilisation of the iron-earth of the *pyrites*; it is certain, that this is not so easily effected with iron itself, as with the iron-particles, still existing in the ore or *pyrites*: and what is decisive, take a *crude sulphur* made in clay vessels, distil or burn it off, and examining the earth remaining behind, with the magnet, *this* latter will be found to attract the *former*.

Whether, and how far, the coppery earth goes in part over, in the distillation, or *desulphuration* of the *pyrites*, along with the *sulphur*, as I have not been able to make *John Agricola*'s experiment, must be left to be considered, and rest upon the truth of his relation, which is as follows:

'Having once made an *oleum sulphuris*, or oil 'of *sulphur*, the *fæces*, or remainder, I reverberated for fourteen days in a moderate fire; afterwards committed them well luted down to a 'wind-furnace, giving for six hours a strong fire; 'then I wanted to calcine the *fæces* quite white, as 'my intention was to make something else of 'them. Now, upon breaking up the crucible, I 'found on the upper part, a few *fæces*, not white 'but grey, and beneath, a beautiful regulus, of a 'blood-red colour, and very sparkling. I won-'dered

'dered what it might be, as being well aware, that 'not the least thing, besides the sulphureous *fæces* 'had come into the crucible. Upon taking out, 'it proved heavy, and tried under the hammer, 'it stretched almost like lead: upon clipping with 'the sheers, it proved internally somewhat yellow- 'ish, but a beautiful fine copper, which gave me 'no small surprize. The goldsmith also, upon 'wire-drawing it, found it not only malleable, but 'of a very beautiful colour. Upon a repeated ig- 'nition and extinction in urine, it had almost ac- 'quired the colour of *crown-gold*. It has been 'often matter of reflection with me, why I procured 'no other metal but copper; for, I well knew 'this *sulphur* was not derived from a copper, but 'from a gold pyrites. But at last I found the rea- 'son: for, though there was not any one mineral 'or metal added, only the *sulphur* first dissolved 'in linseed oil, from which no metal can arise; I 'thus concluded, that a strong metallic spirit, tho' 'deemed only an excrement, and forced off by a 'strong fire, lodges in the sulphur *.'

Many things in this relation want to be cleared up, and much to be remarked upon. In the first place, it is pity our author did not specify the quantity of the *sulphur* employed, and of the copper educed; a piece of inaccuracy but too common with writers on these subjects. Again, he is under a mistake, in that he considers linseed oil, as of little use in the business of *metallisation*; since it is not a bare *transient* but an *immanent* instrument, or rather *materially* contributes thereto.

His making *gold pyrites* and *copper-pyrites* two different things is a mistake, as I have sufficiently shewn

* Joh. Agric. uber Poppii Chymische Artzneyen im tractat. de sulphure, p. 855.

ſhewn above, chap. III. There are ſo many *pyritæ* containing copper, that ſcarce one in a hundred is without it, or that conſiſt entirely of iron. A *pyrites*, that, preferably to another, yields gold, muſt always poſſeſs iron or copper, or both, for its ground-earth. And I have remarked, that ſuch *pyritæ* are ever coppery, nay the very richeſt copper ores; and, in the other caſe, ever purely arſenical, or the *white pyrites*. Now, in the laſt place, whether it was an actual *gold-pyrites*, or no, we are to underſtand, that *pyrites breaking* in fiſſures and veins, is ſeldom without ſome little copper. So that our author might have ſaved himſelf many uneaſy reflections about the cauſes, whence his copper might ariſe; and alſo have ſpared himſelf the trouble of imagining a *metallic ſulphur ſpirit*; as he needed only to have put the alternative; either the copper is along with the *ſulphur* educed bodily out of the *pyrites* in form of the moſt ſubtil earth; or generated, as a new production, out of the *ſulphur*, or its peculiar earth, with the addition of linſeed oil, or its fatty earth; alſo for a certainty, with the addition of the material, fatty particles of the fire.

It is, however, probable, the above copper was not generated but educed: for, in the firſt place, the volatility, or at leaſt, the volatiliſation of all imperfect metals in general, is a plain caſe. (2.) We have a peculiar inſtance in iron, which is moſt proximately allied to copper. (3.) The *ſulphur*, which muſt here ſerve as the vehicle, adheres longer and cloſer to the copper than to the iron. (4.) The volatility of copper aſſayers experience but too often, upon too briſkly roaſting its ore; when they remarkably educe a leſs quantity of copper, than when together with care and time they employ a gentler fire.

Now

Now according as the *pyrites*, out of which this and the other *sulphurs* are *driven*, the *sulphur-flags* of each sort procured, happens to be very irony or coppery, so the earth remaining behind of these flags, may at one time take more iron, at another more copper. Yet it may well happen that in the course of *desulphuration* and purification, some change of iron into copper particles may be effected, by means of the energy of the *sulphur*, as both those metals are proximately allied to one another: by this change or transmutation, no wide leap, but an easy transition rather is produced in nature; not only to the *patient*, namely, the metal, standing highly receptible, but the *agent*, namely, the *sulphur*, in the rank of one of the most powerful in nature; that if common *sulphur* doth not transmute iron into copper, or rather does not fit an irony earth for a coppery one, it will remain for ever untransmuted.

As to the habitude of *sulphur* to the metal-earth, entangled therewith in the *pyrites*; it becomes a necessary question, whether either the *sulphur* arose at the same time with, or whether it gave rise first to the metal-earth, and thus existed previously to it.

That all *pyritæ* were not originally created, but generated at different times since the deluge, and still continue to be generated, is a certain truth, as I have shewn in chap. V. Now let any one imagine to himself a luty, loamy, and the like marly earth-bed, which is peculiarly adapted for the conception of such ore; I there find only one sort of particles, either not manifestly such, or in all respects the same as the *pyrites* consists of; and, as one

one might be apt to imagine, ſuch as it might be ſuppoſed to be run together and formed of.

We ſhall omit mentioning the metallic ground-earth, as being what is at leaſt *in potentia*, ſo that nature may, with eaſe, completely fit it for the *pyrites-mixtion*; nay, which already appears to be pretty well fitted; as art, which is far from being able to call in aid ſuch auxiliary means, or far from having that time for the purpoſe, ſhews the poſſibility, from *Becher*'s famous experiment on loam and linſeed oil, of ſuch earth being proximately fitted for the production of iron, alſo of *pyrites*. But we would only enquire, from whence the *ſulphur* is to be derived to it? On the ſpot, where the generation is to happen, there is none.

But it will, for inſtance, be alledged, that ſuch a lute, wherein the *pyrites* appears to run neſt-wiſe, muſt, e'er the production of the *pyrites*, have been of quite a different mixtion and nature from what it is at preſent; ſo that its preſent ſtate renders it unfit for any further conception. Now, ſhould we ever allow the places for the production of minerals, partly in the ſtate the creation left them, partly as the deluge has affected them by new mixtions to be become more unfit by exſiccations, exuctions, indurations, nay, even petrifications, whence ſhall we then derive the *ſulphur* to the *pyritified* periwinkle and muſcle-ſhells, which doubtleſs owe their riſe to the deluge? Should it be even preſent upon the ſpot, and ſuch earths happen then to be of a quite different mixtion and nature, from what they are at preſent, yet it is impoſſible to conceive, it was formally and actually preſent, or that *flux-wiſe*, like a *ſulphur* melted in the fire, being brought thither, it had, like a ſeed, collected and lodged

lodged itself in certain cavities and matrices, and there concocted, penetrated, and elaborated the matters it met with, and lastly, hardened them into such lumps, balls, *kidneys*, and *nuts*, as we find.

To come to the truth of the matter as near as may be, if not to a positive demonstration, yet a high probability, let us consider those bodies called *druse* and *sinter*.

Upon both these we, among other ores, find *pyrites*, not in a flux or run state, but as so many small stones or crystals, in figure like the following salts; *viz. tartarus vitriolatus*, *arcanum duplicatum*, common salt, &c. which thus usually shoot from their several waters. These cubical and variously angular *pyrites-corpuscles* sit so loose upon the rock and tacks of the *druse*, as to make it evident, they did not sprout out of the subjacent rock itself, but were sprinkled or sown thereon: and really the case is so; namely, that they are damp-wise sprinkled upon these bodies, as I have shewn above, chapter V.

The question therefore is, whether those parts of the *pyrites*, we afterwards discover upon resolving it, existed in the mineral damps in a determined, formal, actual state; or, whether they were not first formed and produced in the course of forming the ore itself? A question of some importance, as it no ways follows, that because upon analysis, we find the *pyrites* principally to consist of sulphur and iron; that therefore it is also necessarily produced from the same materials; nor that, as many might be apt erroneously to imagine, the *sulphur* is the *metallising* principle; things that lodge near, and in each other, are not always to be taken for the natural

mutual origin of each other; though *sulphur*, when actually present, and chiefly in its ore, must be allowed to have some efficacy. The mineral damps, that lodge any where for mineralisation, may happen to be of different *mixtions* and natures, yet, doubtless, in their particles, are still in an undetermined, and, as it were, *chaotical* state; in which, though caught and examined fresh, neither the *sulphur-earth* apart, nor the metal-earth; neither the *dry*, nor the *moist*, are separately distinguishable: either they are found in a kind of seminal state, wherein the parts of the body to be formed are not yet distinctly exhibited or elaborated, tho' they lodge *potentially* therein. And though the receptivity and re-action of the bed or matrix, length of time, the accession of different matters, and other accidental circumstances, have undoubtedly much influence on the formation of different ores; yet I affirm, that in the production of the *pyrites*, we ought to imagine an *influx* of actual *pyrity*, formally *sulphureous*, and corporally *metallic* damps; but to the formation of *sulphur*, *pyrites*, and *metal*, damps proximately and reciprocally adapted, are necessary.

For, in the first place, from the opposite opinion, it must be presumed possible, from *sulphur* and iron earths, to make, or compound the *pyrites*; but of this there neither is, nor ever can be any instance: and farther, supposing that art could exhibit any such experiment; where shall the metal-earth, in the laboratory of nature, be found to be added thereto? On the *druse*, as being quite pure and close, it is not to be met with; and yet there the *pyrites* is often found in great plenty and large masses; to suppose it sprinkled along with the

ſulphur, by way of damp, in a metal form, is as difficult to reconcile with experience.

Pyritæ reſolve themſelves into their preſent conſtituent parts, and forſake their proper mixtion, as ſhall be ſhewn in the chap. on vitriol; but theſe parts thus forſaken, do not therefore remove from each other, nay, do not ſeparate from each other, even for a ſingle moment; but in the courſe of that motion which brings about the diſſolution of the *pyrites*, the ſulphur-acid ſwallows up the iron-earth, and becomes conjoined again in a different manner: what remains ſeparated from this new vitriol-production, may well be deemed no other but the metal-earth; and as to the *ſulphur*, there is little or nothing ſaved, but generally all of it is deſtroyed; yet as there is certainly much *ſulphur* acid requiſite to the production of vitriol; nay, from the very ſmall metal-yield of the *ſulphur*, and ſo much metal-earth or ochre reſidue, we muſt conclude, that were there more *ſulphur* in the *pyrites*, more vitriol would have been generated, and thus more *ſulphur* become incorporated with the iron in the vitriol.

Thirdly, there are other ores that may happen to be ſomewhat *ſulphureous*, and diſſoluble, and by their diſſolution yield *ſulphur*, and form *ſulphureous* damps, or *weatherings*, and yet be leſs adapted to the production of matters, or damps fitted for *pyritification*; wherein the parts of the *pyrites*, eſpecially the metallic, ſhall (if we allow it to contain the *ſulphureous* parts) formally exiſt; ſeeing all other *ſulphur*-ores, that are not *pyrites*, afford no iron, as the latter do.

Fourthly,

Fourthly, from the ſtructure or texture of the *pyrites*, particularly the round ſort, we ſee it is become what it is, through length of time, and by means of coction. The round ſort is either teſtaceous or radiated, and by both ways of ſtructure, it exhibits ſuch proofs of its origination, as are not to be ſought for from an external accumulation, but from an internal concocting, fermenting, tranſmuting elaboration: I ſay, from the origination, or formation of *pyrites*; (and this I mean not of the configuration or external form, but of the internal eſſence and mixtion of the *pyrites*;) for, indeed, an accumulation, not of matters actually *pyrity*, but of matters adapted to ſuch productions, muſt both be granted, and muſt happen. Yet in clayey, loamy, ſhivery, marly beds, where *pyrites* is peculiarly found in *kidneys*, ſo large an accumulation of matters, derived from other quarters, is not ſo much to be expected, nor is it neceſſary (as there the ſubjacent fine earth, at leaſt the iron portion, contributing to the formation of the *pyrites*, is already proximately prepared for it; which, to its concentration, collection, and mineraliſation, together with ſome acid, or even ſulphureous damps, only wants ſome degree of coction) as in thoſe *pyritæ* rather, that lay upon *druſe*; where nothing earthy is obſervable; from which, as from a *ſubtratum*, ſo much metallic matter, as is to be found in *pyrites*, could have been generated.

Upon the whole, the *ſulphur* in the *pyrites* firſt truly becomes what it is, and was not before formally therein; in the ſame manner as other fixed *pyrites*-earths, which, (previous to the *pyritification*, were crude, though not ſo very foreign to

this work) must by coction be more proximately prepared, and rendered metallic.

Now, in order to answer the question; *viz.* what analogy the *sulphur* in the *pyrites* has to the metal-earth, we must here distinguish the times. First, if by it we intend only the primordial origination of the *pyrites*: in this sense, the sulphur in the *pyrites* is not the *metallising*, nay, not the *mineralising* principle; for, how should it, when it did not exist? And though the inflammability of mineral or mineralising damps shews somewhat of a *sulphureous* nature, yet it does not follow, that they are positively *sulphureous*: thus the acid of such earth-*weatherings* shews a part, and not the whole of the *sulphur*.

But, were we to speak with propriety, not of the *sulphur* itself, but of the parts that are to become *sulphur*, it ought to be observed, that in the business of generation, the matter may be considered as *active* and *passive*; the former as the most tender, fugitive, and penetrative; and the latter (or what is to become the metal) the heaviest, coarsest, and densest: though in generations, that is, in productions of a third thing out of two others, both parts so act and re-act, as thereby to form a new production.

(2.) If by the question be meant the analogy of the *sulphur* to the metal-earth in the *pyrites* already formed, such as we find it: to me it seems like the juice, in respect to the remaining dry body; or, as a material cause and property of *mineralcity*; according to which the *pyrites*, like all other proper metal-ore, is distinguished from a formal metal,
or

or formally metallic earth; on which score, *pyrites* may be called, neither an iron-earth, nor iron itself, but a *sulphurated* iron, or iron-earth: and lastly, that the *sulphur* and iron-earth are mutually moved or acted upon by each other, and connected together, like two members or links in a chain: where there is neither *agent* nor *patient*, but both are equally *passive*; in which case a third body must intervene; as happens in the vitriolisation of the *pyrites*; where not only the chain, but each link therein, breaks asunder, namely, the *sulphur* in particular, ceases to be a *sulphur*, and commences to be, what it must be, for exhibiting a vitriol.

This third consideration leads me to a circumstance the most important of all, and which gave occasion to this question, which otherwise may possibly appear useless; namely, an opinion, that the metals in the ores do, by means of the *sulphur*'s activity, not only grow, but become more enobled: a surmise, which, if it doth not unhappily betray the enquirers into all the false conclusions and vain idle processes about metals and their melioration, yet it helps to prevent the discovery of other useful, practical truths. For, tho' we are ready to confess *sulphur* a very powerful principle in the mineral kingdom, yet in any capital imitation of nature, we are not to strain or over-do our conceptions of it.

Where then is the *sulphur* or agent in such processes, when two bodies, which partly are only a crude, unsaline, unsulphurous, nay even unmercurial earth; and partly, a metal already smelted out of its ore, come together into union, and such a degree of motion, as that the first not only incorporates with, but also proves similar to the second;

consequently, to be corporally metallic, nay a noble metal; as the celebrated *Stahl* knew an instance of a certain earth and a silver; and which was not unknown to other operators? And is then fossil calamy, which not only tinges, but also in its very substance enters into the body of copper, and therewith becomes metallic, a *sulphur* also, or derived from *sulphur*? I cannot find it is.

Finally, *sulphur* certainly is a powerful, active, mineralising, and peculiarly operative matter, not only in respect to that metal-earth, with which it was blended, and constituting, for instance, the *pyrites*-mass, but also, after separation from the *pyrites*, or any other body, in regard to other foreign earths, with which, after due preparation, it is put in a proper degree of coction: and this is the third analogy of *sulphur* intended by the above question.

The first was the analogy of the *sulphur*, or rather of the parts that were to become *sulphur*, to the metallic earth, or the earth that was to become such, as we may conceive it in the first formation and production of the *pyrites*. The second, the analogy of the *sulphur* in the *pyrites* already formed, as it now is, in a seeming state of rest or inactivity. The third, its analogy, out of its mineral, when separated from it, or even left therein, and something else applied, with which, by means of the external warmth, it may be brought into action.

'Tis however certain, *sulphur* manifests something that is active, powerful, and operative, nay maturating, graduating, and transmuting, both in its separate and combined ore state; sometimes

times more one way, ſometimes more another, according as the ſubject happens to be qualified by nature, or prepared by art; alſo according to the nature of the fire, the proceſs, and other circumſtances.

As to *ſulphur* in its ſeparate ſtate, 'tis certain, it mineraliſes, or reduces metals to an ore-ſtate: in particular, this holds good of lead, which it reduces to a form, tho' more earthy and ſooty, and thus very indiſtinct; yet ſuch a one, as will here and there eaſily manifeſt ſmall eyes of *glitter* interſperſed.

It reduces alſo to an ore-ſtate the regulus of antimony, ſo as to make it greatly reſemble a crude antimony. It turns quickſilver to cinnabar; ſilver, eſpecially when reduced to that white calx, from which the *Lunæ cornua* is made, to a maſs, little or nothing diſtinguiſhable from that richeſt ſilver-ore, called *glaſſy*. It alſo mineraliſes tin, yet ſo, as to appear like an antimony rather than a tin ore.

Further, *ſulphur* metalliſes crude earth, from which otherwiſe no metal would be procurable; yet, with this remarkable difference, that it ſooner reduces it to a noble than ignoble metal: as to the production of theſe laſt, a part only of the *ſulphur*, namely, its fattineſs, is better adapted than the whole body of the *ſulphur*. It exalts the earths of imperfect metals, and makes them approach conſiderably near to ſilver, and probably to gold, as I found by experience, after having found out, and duly worked the proper ſort. This I can with confidence affirm of the *reguli* of lead and antimony. And I conclude from experience, that the hiſtories

of the many lead and tin processes mentioned by Kelner, ought not to be rejected, as they certainly carry appearances of what has really happened, notwithstanding many others have miscarried in their attempts, to imitate his experiments. To them also belong the cinnabar-processes, where again the *sulphur* comes principally in play, and which, by passing through the hands of impostors, have fallen into discredit.

On the head of the lead and tin processes I shall only mention, that the business depends, in some measure, on the due preparation of the metal or earth, particularly on its most intimate subtilisation; to the same purpose is also necessary such a degree of warmth, as that the *sulphur* shall just come to exert its activity, without being made to run. As to the *sulphur*, while yet in its ore-state, I have made numerous proofs with *sulphur-pyritas*, and found, that in certain circumstances, there may, in regard to the exaltation of the metallic earths, or the metallisation of the crude earths, something be performed therewith, which is not performable with *sulphur* alone. And this is a sufficient hint, without being more explicit, to a diligent enquirer into nature.

But I cannot help observing: (1.) The extraordinary nature of native calamy; namely, that an earth, such as that properly is, which of itself affords no metal, except a very inconsiderable share of iron, should, upon being mixed with a body appropriated to it, for instance, copper, become almost intirely, as is well known, metallic, and incorporated with the copper, without destroying its malleability, and consequently its true metallic character.

(2.) That

(2.) That taking certain lutes, as chalk, and roasting it softly and gradually along with *pyrites*, a *silver-grain* will certainly be procured, otherwise not procurable from such an earth, and which consequently may be justly affirmed not to be in it, but rather maturated, concocted, made, or transmuted by it.

Lastly, That here we seem to discover a foundation, that may tend to the improvement of smelting ores; not to mention the iron, lodged with the *sulphur* in the *pyrites*, which principally contributes to the business of fluxion and separation.

As the metallic earth, joined with the *sulphur* in the *pyrites*, is two-fold, namely, iron and copper, the former at all times, the latter often at the same time therein, it remains to enquire, what their different connection with each other usually is.

(1.) Sulphur endures being separated very easily from the iron earth, so as sometimes to lie loose therein; whereas it clings more closely to the copper earth, insomuch that it is often perceived to flux along with, rather than part from it; as appears not only from copper-proofs very readily caking together, but from the *copper-stone* at the huts; which, after having gone thro' a number of fires, both in roasting and smelting, still exhibits many large lumps in the form of real yellow copper-ore. 'Tis true, arsenic, which always lodges in the copper-ore, but never in pure *iron-pyrites*, may be the means of this closer union; nay, is of itself alone capable of effecting this, and with its metallic earth adhering to it, of coming into an intimate union, namely, into flux; as it directly shews this (upon commit-

ting

ting it to a sudden brisk fire in a crucible in the wind-furnace) in *Misspickel*, along with that earth, which, in a great measure, is martial, and moreover, very crude. The reason, doubtless, is, that arsenic, as a semi-metallic body, comes nigher than *sulphur* to a metallic earth. Such union, however, must also arise from the nature of the *sulphur* itself, as shall be hereafter shewn from *composition*; where I have treated both iron and copper with *sulphur*.

(2.) That sulphur may be found, in a quite crude cast-iron; for we need not prove, but certainly admit, from the history of the operation of *crude-smelting*, and also frequently in forged iron: but then this must be owing to an undue degree of scorification, and consequently to the mineral *sulphur* not being properly separated, as the coarse grain and brittleness of such iron plainly shew: but, if you take a fine tough iron, or, which is better, a steel; must it not then be granted, that, if the *sulphur* educed be not the common mineral, but a proper, metallic *sulphur*, appertaining to the essence of the metal, it should be found in all, even the best sort, as a necessary constituent part: but, from the *ground-mixtion* and essence of iron, there is properly but one, not a two-fold sort, and so far no sulphur to be shewn from any one.

'Tis certain, we plainly observe in *cast* and the like crude iron, sulphur a constant companion, nor is it a stranger in *black-copper*. Now the question is, whether it holds firmer and longer in the iron or the copper.

If we reflect, that the *pyrites mixtion* consists in no such composition as might be supposed to arise from the running together, in concocting and smelting

ing ſulphur, and a metal-earth, but in a production or generation, and thus in an internal ground-union, as has been often mentioned; where then ſuch accurate ſeparations, as that one part ſhall not either ſwallow up, force over with it, or keep back ſomething of the other, are neither credible nor poſſible, the caſe will prove eaſy. Again, let us conſider what a number of times copper muſt paſs thro' the fire, in roaſting and ſmelting, 'ere it only becomes *black-copper*, whereas iron-ſtone ſcarce wants a ſingle roaſting, being directly conveyed to the tall furnace.

(3.) Conſider only the violence of the degree of the fire in the tall furnace for iron, above that in the furnace for copper; ſo that, by the ſudden briſk flux, the ſulphur ſeparates not ſo accurately from the metal earth; but becomes, in ſome degree, incorporated with the metal; whereas, by a more gentle fire, it might more accurately and much ſooner be ſeparated than from the copper; as I obſerved from meaſuring the time for roaſting the proofs of copper ores and iron-ſtone: tho' there may be inſtances where the contrary may happen, and this may be owing to this or the other admixture; yet, it happening more rarely, we muſt abide by what more generally occurs.

Iron, in whatſoever manner treated, does not ſo readily as copper admit *ſulphur*. The moſt feaſible method I know of is, firſt, to ignite the metal well, and then convey the *ſulphur* upon it; when the copper actually mineraliſes, entirely loſes its colour and metalleity, turns of a grey caſt, almoſt like a fallow ore, and increaſes in weight about a fifth: whereas iron not only remains without the

leaſt

leaſt increaſe, but alſo unaltered in colour and malleability, and therefore not the leaſt penetrated by the *ſulphur*. What unfits iron for receiving the *ſulphur*, is its eaſily burning away, and turning to an earth, ſooner than copper, whereby the due introduction of the *ſulphur* into it is prevented. 'Tis true, copper, by the art of ignition, becomes covered over with a kind of ruſt, or ſcales, which at length, are eat thro' or penetrated by the ſulphur; whereas iron will receive none of it, only ſuffering it to ſettle a little externally thereon, be the degree of fire as great again as for the copper, and thus be the ingreſs of the *ſulphur* facilitated as much as may be.

Here might be expected a fuller and more particular examination and deſcription of *ſulphur*, but as this would require a great deal of time and labour, beſides, not properly belonging to our preſent undertaking, where I enter not into a particular detail of the parts of the *pyrites*, I wave it. My deſign is the analyſis of the *pyrites*, not the hiſtory of each conſtituent part in particular; though, on the ſcore of inferences, connection, and other circumſtances, I could not always avoid the hinting at this, and ſome other matters, not immediately neceſſary to the knowledge of the *pyrites*.

A reader deſirous of ſomething peculiar, fundamental, and explicit on the head of *ſulphur*, may conſult Stahl, in his *Bedencken vom ſulphure*, his *Specimen Becherianum*, his *Menſis Julius de experimento novo verum ſulphur arte producendi*; where he will find full ſatisfaction.

There ſtill remains to be conſidered M. Homberg's relation, in the memoirs of the Royal Academy

demy of Sciences at Paris. Now, though Stahl, in his *Bedencken*, has made much mention of it to all useful purposes, yet, as I find this sulphur-history to be still very defective, being proposed by this ingenious person only as an essay, it may not be improper, or unuseful, to insert here, at large, his whole relation (from which Stahl has only selected one single part, or experiment) together with some remarks and experiments of my own; especially as he brings many experiments, which deserve a serious attention in the history of nature. His account is as follows, under the title of, *An essay on common sulphur*.

'All those matters called sulphureous, are so 'entangled and blended with earthy, saline, and 'aqueous particles, as very rarely to deserve the 'name of *sulphur*; in chemistry usually applied, 'without distinction, to the inflammable matters, 'as, common *sulphur*, bitumen, oils, *&c.* Some'times they are also considered as certain mat'ters, especially among minerals, in no manner 'inflammable, and must be called *sulphur*, merely 'on account of their colour: so that we see this 'appellation applied to things of quite opposite 'natures, and men appear still to have very con'fused notions thereof, nay, to be almost quite 'ignorant of what *sulphur* properly is. Now, *sul*'*phur* is one of the most considerable *principles* in 'chemistry.'

Here I would hope, that by the term *principle*, he means not a simple or original principle, as will appear from what follows.

'Wherefore as in this art it must be known, in or'der to the forming a rational judgement of it, it ap'peared

'peared to me a matter of importance to examine 'its nature and characters, and learn to distinguish 'it from the other principles, &c.'

'Common *sulphur* appears to me to have been 'compounded of several matters; as (1.) an 'earth, (2.) a salt, (3.) a fatty, inflammable 'matter, and (4.) some metal. The three first are, 'in weight or measure in it, in a proportion of 'equality, nearly, and almost constitute the whole 'mass of the *sulphur*; from which I premise, that 'by means of sublimation, it is purified from its 'superfluous earth, nothing of it remaining, but 'only so much as the fire could have carried up 'along with the other principles,' (rather, that nothing of it went over, but what the fire, &c.) 'the produce of this sublimation we commonly 'call *flowers of* sulphur. The metal, to be found 'in common *sulphur*, is in so small a proportion, 'that it may be overlooked.'

What is become of the water which he afterwards alledges as an essential part of the *sulphur*, though from a false inference? How shall one, from pure refined *sulphur*, which must be what is here meant, make out, and lay down for n° 1. a peculiar earth, that belongs neither to n° 3, nor n° 4, but may be distinguished from both; seeing these two parts are very sparingly, and the last, by his own concession, almost undistinguishable therein?

'By a single process, the matters which make, 'or constitute common *sulphur*, are not readily 'separable from each other, both on the score 'of their close connection, and on account of the 'great volatility of the inflammable, fatty matter

'of

'of the *sulphur*, which almost always carries along
'with it the other three principles.

'In a close fire, namely, in sublimation and 'distillation, all the four parts of the *sulphur* ascend and pass over together, without undergoing the least degree of alteration in their *mixtion*.

'In an open fire they are also dissipated together, yet, in this operation there happens a separation of the fatty principle, which separates in the flame, from the saline; the saline unites with the moisture of the air, and makes what we call *spirit of* sulphur; by this means setting itself free from all inflammable fattiness, so that no remains of it can be observed. This spirit of *sulphur* is only the acid salt of this mineral, and, in every respect, resembles that from vitriol.'

''Tis difficult to ascertain the quantity of this acid salt in common *sulphur*; for, the operation whereby this salt is procured, is commonly performed by the accension of the *sulphur*: now as no accension can happen without a free access of air, most of this acid of the *sulphur* is dissipated and lost; we, however, sometimes procure more, sometimes less, in proportion both to the skill of the artist, and the quality of the air. I employ a peculiar method for the purpose, so as from a pound of flowers of *sulphur*, to have sometimes an ounce, sometimes an ounce and a half, as follows.

'I take the largest glass receiver I can get, and make a hole therein, between eight and ten inches broad; this glass I hang, like a bell, quite

'close

'close over an earthen pot, which, at the top, is 'about five or six inches in diameter; in this pot 'I previously melt between 10 or 12lb. of *sul-* '*phur*, 'till quite full thereof; then I set the *sulphur* 'on fire, so as to burn all over its surface; after 'which I place the glass as close to it as may be, 'without extinguishing the flame; the acid spirit 'trickles down into an earthen glazed vessel, in 'which the pot, containing the burning *sulphur*, 'stands upon an inverted dish: in this method, 'which generally succeeds well, between five or 'six ounces of spirit of *sulphur* may be procured 'in the space of twenty four hours *.'

A like

* Mr. Seehl, in his paper, containing, An easy method of procuring the volatile acid of sulphur, recommends the two following ways. Process I. Take a pound of the flowers of brimstone, and five pounds of dry fixed alcali salt, grind them together, and put the mixture into an iron pan; add, by degrees, a little water, so as just to dissolve the fixed alcali; gradually dispose the whole to boil, in order the better to dissolve the sulphur; when these have boiled for a quarter of an hour, add more water, by degrees, and when the sulphur appears to be dissolved, filtre the solution, evaporate it to perfect dryness in an iron pan, 'till it almost begins to melt; then take out the dry powder; when cool, put it into a tubulated retort, which being placed in a sand-heat, and a receiver luted on, pour in at the tube, by degrees, two pounds of rectified oil of vitriol, and immediately secure the tube with a stopple of chalk, luted, and luting: then give a gradual fire for some hours, till the volatile spirit is come over; after which, let the fire go out, take off the receiver, and carefully pour the liquor into a glass phial, to be closely stopped with a glass stopper. The volatile spirit thus procured will be about twelve ounces in weight, and appear tolerably limpid, smell extremely quick, pungent, and *gassy*, or sulphureous. Process II. Take a pound of the flowers of brimstone, four pounds and a half of fixed alcali salt, grind and mix them well together, put the powder into an iron pan, over the fire, add a little water, by degrees, to dissolve the salt, then boil gently for a quarter of an hour, add more water, and afterwards three pounds of strong quick-lime, let all boil together for a while; when the solution is

A like contrivance we find in Lemery's *cours de Chymie*, and which Homberg, but with no small degree of improvement, in regard to the bigness of the glass, (the former employing only a glass funnel) may have probably borrowed from him.

' This process, 'tis true, coincides with the usual ' method by *the bell*, but much altered and im- ' proved, as by the former there is much more pro- ' cured than by the latter method, which is princi- ' pally owing to two improvements; the first, in ' the large receiver employed instead of the glass ' garden bell, which in circumference is much too ' wide, and in internal capacity much too small ' and narrow, that but a little can settle thereon, ' when much must evaporate, and be quite lost; ' whereas the fitted receiver has a small aperture, ' and internally a large width, whereby the large ' evaporation is obviated, and a more abundant ' collection promoted. The other improvement ' regards the quantity of the *sulphur*, there being ' formerly too little *sulphur* put in at once, and ' that often scarce melted, consequently, the acid ' not so capable of ascending, especially in such ' quantity as one would willingly have it; which ' is so true, that when the pot holds not more ' than 10 or 12 lb. when not always full, and ' when the *sulphur* is not thoroughly melted quite

 ' down

is compleat, filtre the lixivium, and evaporate to a dry powder, as in the first process; put this powder into a tubulated retort, and pour on, by degrees, a pound and half of rectified oil of vitriol; proceed to distill, as before; and thus you will obtain about eight ounces of a more strong, and more volatile acid spirit than the former; of a yellowish colour.—Our author owns it was Dr. Stahl's method that gave him the hint of doing the same thing in a better manner.

'down to the bottom of the pot, the *sulphur* gradually consumes, and we can procure but little or nothing of the acid salt of the *sulphur*.

'You must be careful to clear the upper surface of the burning *sulphur* with an iron wire, or rod, as there settles on the top an earthy skin, which not only of itself gives no flame, but also quite smothers what does; this only holds good of that *sulphur* which is whitish, blackish, or of a greenish cast, a beautiful yellowish *sulphur* being subject to no such accident'.

Here M. Homberg takes notice of a difference between *sulphurs*, as they happen to be crude and purified, the latter of which must be always of a beautiful citron-yellow, the former being generally of a greenish cast, and sometimes inclining to an orange colour, from its containing something foreign, particularly arsenic, which belongs not at all to the nature of the *sulphur*, and is separable in the refining.

'Though this process affords more of the acid spirit of *sulphur* than the common method by the bell, yet still much of it is lost, as may be easily perceived by the strong sulphureous smell about the vessels; so that hence we cannot learn what is its due quantity and proportion in the *sulphur*.

'This acid spirit is entirely separated from its inflammable fattiness, and highly adapted to become a volatile, and almost insipid salt, like the acid spirit of vitriol itself, which it greatly resembles, nay, I might say, is one and the same with.'

What

What our author means by *the volatile and almost insipid salt*, I cannot conceive; a volatile, namely, a spirit of vitriol, becoming *sulphureous* by means of a fatty addition, I well know, and yet so insipid is it, as to be corrosive. I have also a dry volatile acid salt, but powerfully corrosive with all manner of lixivious salts. Would we abstract a spirit of vitriol over lixivious salts, and call what goes over (which is a pure phlegm, set free from its acid salt) an edulcorated spirit of vitriol, as some have fancied to themselves, we might then indeed procure something insipid, but something, at the same time, separated, the acid of which was not edulcorated, but left behind in the alcali; and thus, neither a salt, much less a volatile salt, but a pure plain water.

'This then is one of the principles of the *sulphur*, namely, its salt, loosened from its other 'principles, but mingled a-new with the universal receptacle of acid salts, namely, the moisture 'of the air: the fatty, inflammable, as well as its 'other earths, are, by evaporation, lost in the 'air.'

'By the following process I have separated the 'parts whereof common sulphur consists, so that 'each may be exhibited apart. Put into a body, 'or cucurbit of two measures, four ounces of 'flowers of *sulphur* (or fine-rubbed *sulphur*) pour 'thereon a pound of oil of fennel, or turpentine, 'let them stand together for eight days in strong 'digestion, and the oil will dissolve the *sulphur*, 'and acquire a highly red colour; let them cool, 'and you will find the *sulphur*, to the quantity of 'about three ounces, shot at the bottom into yel-

'low needles. Pour off what is still fluid, save 'it, and pour on again a pound of oil, and set 'it again to digest, as before; when the vessel is 'cold, pour off the fluid, and you will find the '*sulphur* remarkably less in quantity: repeat this 'four or five times, 'till all the *sulphur* is dis'solved. Put all these solutions together into a 'glass retort, (because the matter is apt, in the 'end, to froth much) and distil for twelve or fif'teen days and nights, by a very gentle fire, and 'there will come over about ⅔ of the oil employed, 'colourless, and quite clear, and with it about 'four ounces of a whitish, ponderous, and vitri'olic acid water, after this, red drops of oil: then 'apply another receiver, gradually increase the 'fire, and in seven or eight hours you will have 'forced off all you well can: instead of a receiver, 'you may employ a glass retort: most of the oil 'turns, at last, very thick and high-coloured, on 'which still floats something of a whitish, highly 'acid water: in the retort there remain betwen 2 'and 3 ½ ounces of a black, spongy, shining, in'sipid matter, which will neither kindle, burn 'white, nor suffer any remarkable loss in the 'fire.'

'Re-distill the matters found in the several re'cipients in a very gentle fire, for some days and 'nights, in order further to separate the remain'ing oil from the acid water: upon the residuary, 'bituminous, black matter, pour half a pound 'of good spirits of wine, and distil very gently; 'pour again fresh spirits thereon, and repeat this 'so often, 'till what goes over carries along with 'it no more bad smell.'

'These

'These distillations, performed with spirits of 'wine, carry with them, from the black bitu-'minous matter, those parts of the *sulphureous* 'acid, that would not come over at the first: 'now as the spirits may, together with the acid, 'discharge all the rank smell, which solutions of '*sulphur* commonly have, so I am perswaded, the 'acid of the *sulphur* may be the cause of this into-'lerable stench:' (in part, indeed, not solely, but with the addition of a burning fattiness.)

'Now, in order to guess at the quantity of the 'acid and salt procurable from four ounces of flow-'ers of *sulphur*, I took two ounces of salt of tartar, 'well dried, and dissolved in common water; I 'poured thereto all the whitish acid water, pro-'cured from the said *sulphur*; and, after efferve-'scence, evaporation, and drying, I obtained as 'much salt as came to above three drachms, six-'teen grains.'

Then, according to this process and calculus hitherto, there are in four ounces of *sulphur*, three drachms and sixteen grains, provided M. Homberg has employed enough of the salt of tartar, and something of the *sulphur*-salt unentered into it, did not remain behind, as the alcali, employed for the purpose, appears to me to have been too little.

'The first remaining black matter I put into 'a crucible before the *blast*, and ignited it, when, 'indeed, it fumed a little, and smelt of burnt '*sulphur*, also was encreased about two drachms, 'but found unchanged in the least, either in co-'lour, taste, or sponginess.

‘ I afterwards placed it in the focus of a burning-glaſs, but could neither make it take fire, nor melt it; only it boiled, and gave forth a ſmell of *aqua fortis:* after leaving it in the fire ſo long, 'till it fumed no more, I found it decreaſed almoſt an half, and what remained appeared black, ſhining, flaky, inſipid, and in no manner altered by the burning-glaſs.’ (This is, certainly, a circumſtance that merits great notice, in particular, that it ſhould refuſe to yield to one of the moſt quick and violent fires of vitrification in nature, namely, that of the ſun.)

‘ Now, this matter I ſuppoſe to be the earthy part of common *ſulphur*. I weighed it, and found it to be one ounce, and almoſt one drachm, that is, about ¼ of the whole:’ (that is, of four ounces of *ſulphur*.)

‘ Now, as I could not force it by the burning-glaſs alone, and *per ſe*; upon adding a little borax, it melted to a glaſs of a grey-brown colour: this glaſs, after ſtanding for ſome time in a moiſt place, I found, at laſt, ſtrike a grey-green efflorescence all around; whence I learn, the *ſulphur* employed in this proceſs, to have held ſome copper, but in ſo ſmall a quantity, as to be inſeparable from it in a metallic form.’

‘ The fume ſtill forced out by the burning glaſs, is, in all appearance, the remains of the fatty earth and acid ſalt of common *ſulphur*, which the common fire could not force out. I apprehend this fume to have contained as much oily matter as acid ſalt; conſequently, in this *caput mortuum*, to be about three drachms of ſalt more, which,

‘ with

'with the three drachms and sixteen grains above,
'make six drachms, that is, $\frac{1}{6}$ in four ounces of
'flowers of *sulphur*, &c.'

This account our author [M. Homberg] has spun out to a still greater length; but as what remains behind does not relate to the history, but his reflections and thoughts thereon, I shall only extract a couple of articles from it, and illustrate these, and some of the foregoing, with some remarks.

In the first place, 'tis not the true method of analysing a subject into its essential parts, to make use of *additions*, that may afford any suspicion of closer mixtions, and new inseparable eductions. *Sulphur* and oil are so nearly allied to each other, that nothing can be more so. What can we suppose to be in oil, proper for making separations? And how indifferently too does the separation come out, especially when we consider the remaining black, unvitrifiable earth?

(2.) Is it also certain, that the assigned sixth part of acid salt was all of it derived only from the sulphur; and may not the vegetable acid, such as may be plainly shewn to be in oils, contribute something also, and how much?

(3.) The three last drachms, separated from the remainder by the burning-glass, our author only suspects to be an acid salt of *sulphur*, he cannot prove it, like that gone over in the distillation.

(4.) Doubtless, the oil has also left behind it not a little of a coaly earth; how then can all the matter remaining over be ascribed to the *sulphur*?

 Nay,

Nay, how can the half, or a fourth only; seeing oils *per se* contain not a little earth, and more than a little oil was employed in this process; on the contrary, the *sulphur* consists least of all in an earth, but almost entirely in the acid salt?

(5.) Are all greens the effect of a copper? Does not alcali with acid, also with *sulphur*, make a green? Though I allow *sulphur* a copper-earth, which is only to be shewn with sal-ammoniac, or spirit of urine.

(6.) Has he sufficiently reflected, when he expresses his surprize at the quantity of the water gone over, and which he might also have easily supposed in oils, that in the explicit enumeration he above makes of the principles of the *sulphur*, he has there left it quite out, and would here reckon it for one? For the rest, this experiment is so far ingenious, that not only a large quantity of acid salt is educed, but an extraordinary proportion to its quantity in the *sulphur*; and it is no small commendation to M. Homberg, that he has shewn so much diligence in the examination of natural bodies, and discovered such a number of truths, that we scarce find many to have equalled him in this respect.

CHAP. X.

Of the Arsenic in the Pyrites.

WE are here distinctly and orderly to shew, whence *arsenic* proceeds, what it is, and what analogy it bears to other bodies; it being a dangerous subject, few are very fond of entering into an intimate familiarity with it; for which reason, it is a matter hitherto but little understood.

Arsenic, in its proper, entire form and colour, greatly resembles a white metal, nay, almost its own ore, *misspickel*, also *cobald*; but in its texture, its relation to the fire, air, and hammer, we soon find it differ considerably from the nature of genuine metals, nay, something from that of the semi-metals: and I know not whether I should allow it to have something more, or something less than these.

In itself it melts in the fire, not as a metal usually does; nay, not even as a bismuth or regulus, unless something fixing, as iron, be added to it, without which it begins directly to fume, and so flies entirely off. Thus it is fugitive; but in close vessels returns again to its pristine metallic form; nay, though *regulated* by means of iron, not a little of which goes to make up the regulus, yet, by a gentle roasting, it not only separates again from the iron, but, by sublimation, recovers its former state. Under the hammer it manifests a great

degree of brittleneſs, and hence evidently appears to want a principal characteriſtic of a genuine metal; nay, it is not, like zink, ſemi-malleable, but quite brittle, like a biſmuth and regulus.

In the air it becomes black all over externally, whereas freſh out of the retort, at leaſt for the moſt part, it is of a ſhining bright, like a mirror; and each freſh fragment or ſhiver of it, broken in the morning, has a black ſkin upon it by night; ſo conſiderable is the ingreſs of the air into this, that the like is not known in any other metalliform body, either biſmuth, or regulus. It is further remarkable, that ſome genuine, though imperfect metals, as iron, copper, and lead, are more obnoxious to the action of the air than theſe laſt, as appears by the ruſt, verdigreaſe, and ceruſe, they ſeverally yield. In a word, *arſenic*, in its genuine form, is a ſemi-metal, a middle metal, and a fugitive metal.

But *arſenic* is, in this ſemi-metallic form, leaſt of all known, appearing not ſo often therein, as in other forms; and thus I am obliged to deſcribe it in every diſguiſe it wears, both as exhibited by nature, and the various proceſſes of art.

Arſenic appears either in a reguline, a powdery, or a glaſſy form; or as mineraliſed, or reduced to an ore-ſtate, a *ſlaggey* and ſtoney body. In a reguline form, it is found either ſublimed, and forced off, or as if caſt in a cone, like glaſs of antimony.

Of the ſublimed I have ſpoken above, and muſt ſtill add; firſt, that thus it is extreamly flakey, light, and porous, and unlike any other ſmelted reguline

reguline body; again, that it then discovers something very peculiar, and worth noticing, particularly, its easy receptivity of the action of the air, and of the smutting or blackness thence arising, which is observable of no other metallic body whatever. Moreover, from this smutting by the air, we may probably infer, if not the formal presence, yet the production of the fatty, inflammable matter; since this blackness is equally as fuliginous, or sooty, as that generally in the sublimation from the *white pyrites*, preceding, and sometimes partly accompanying this volatile *arsenic* regulus; yet there to be considered, not so much a part of the regulus, as of the *pyrites*. Now, whether this smut or blackness be an actual sulphur, and thus not its inflammable part alone, is not so easy to determine, as it cannot be separated, and brought to any test; yet the first is the more probable opinion.

As (1.) the fuliginous form shews, if not a total resolution, yet a superficial corrosion, rather than a new production; and yet this last should here seem to be the case, as neither in the subject alone, the *arsenic*, nor in the agent alone, the *air*, a genuine formal sulphur can be exhibited: and further, as white *arsenic* itself may, by the addition of only an inflammable, not a sulphureous matter, become, after a new sublimation, smutted again. Now, in this form *arsenic* is denominated *fly-stone*, *fly-poison*; in regard flies, and the like insects, are by its means destroyed; though the above black powder be fitter for the purpose, as, on the score of its tenderness and porosity, it is more communicable of its virtue to the water tempered therewith: and the appellation, *stone*, has been borrowed from the fossil, or native *fly-stone*, which is a real

a real ſtone, or ore, and put to the like uſe; tho' the ſublimed neither ſhews like, nor contains any thing referable to the nature of a ſtone. And here the difference between native and factitious *fly-ſtone* is carefully to be obſerved, which you have, when the experiments exhibited therewith happen not to coincide; in regard the native, on the ſcore of its incidental admixture, proves, at times, to be ſomething different.

In a powdery form *arſenic* is of ſuch a degree of tenderneſs, or ſubtlety, as therein not to be exceeded by the moſt impalpable powders; and of different colours, as, black, yellowiſh, grey, and white; yet, moſt frequently, of the white grey. When it appears white, like a beautiful meal, or flour, which happens to it in the fining, it proves right pure; and by how much the whiter, ſo much the leſs is it ſullied with foreign admixture; if grey, it contains ſomething of a ſooty, inflammable, nay, a metallic earth; as appears from the grey *poiſon-meal*, often collected from the vents of the *tall furnace*, with ſome lead, and a little ſilver amongſt it; if black, it contains ſtill more of ſuch a coaly earth, to which colour it never arrives in a large and open, but only in a cloſe, ſmall, and ſudden or briſk fire; if yellowiſh, which colour commonly runs to an orange, it has then ſome ſulphur along with it.

Theſe various incidental colours proceed chiefly from the incidental ores along with it, as well in regard to theſe ores themſelves, as their various admixtures, which may be either accidental, or procured by deſign: where, for inſtance, the ſulphur, when lodged in an ore, and riſing together with the arſenic, muſt needs make it of an orange

orange colour. Yet, the kind of the fire and furnace, where the ore comes to be treated, is, in this case, certainly, of great consequence, not only as to the production of the several colours of the *arsenic-meal* (the sooty matter either burning away and dissipating, or remaining therewith; the sulphur either softly retiring apart, or being hurried or laid hold of by the *arsenic*) but also as to the corporal form, in which it appears: for instance, the *poison-pyrites* yields, indeed, in the open air, a mealy, commonly a grey powdery *arsenic*, but in close vessels appears of a flakey, reguline form. Thus, it is one thing to *drive* or force it off in retorts, subliming vessels, and the like, where the ore is out of the contact of the fire, and where the *arsenic* acquires its proper reguline form; another thing, to force it off in *roasting furnaces*, as is done at the cobald and tin huts, on occasion of roasting the cobald and tin ores, where, by means of the adjoining wind-furnace, the actual flame, and fatty particles of the fire, play over and through the ore. The case proves yet different in smelting furnaces, where not only the flame of the coals, but also the fatty, and at last the alcalised coals themselves, exert their efficacy on the ore; besides, the force of the blast volatilising and carrying off along with the *arsenic*, not only crude earthy particles out of the ore, brought to the highest degree of activity by the strong glow, but also metallic particles themselves, as coppery, leady, and silvery. Lastly, there is a further difference in open roasting hearths, where the ore is not only exposed to the immediate contact of the flame and coals, but to the actual influx of the air, weather, and rain; whence we are enabled to observe in fume-powders, that variety of colours, as, white, grey, and yellow, which, under covered and close furnaces, does not so easily happen.

Now

Now where it cannot thus, on account of the reasons mentioned, arrive to its proper semi-metallic form, but, according to the particular method of operation, happens to be dispersed, it proves no other than an earth, an ash, or a calx of a metallic body, whose metalleity may be destroyed, and again restored.

Thus it rises in the operation of roasting in the tall furnaces, and copper-furnaces, and settles wheresoever it finds the first cool and quiet retreat; in the tall furnaces, indeed, it seeks the highest; and where the air has once taken due hold of it, it is thereby dissipated to a considerable distance; and this, at the mines and huts, is called *hut-fume*; however, this, which is a pure arsenic meal, is not to be confounded with calamy, though they are not unlike in colour; but the former settles lower down, whereas the other is by the fire driven much higher up.

Arsenic also lodges in zink and calamy flowers, in sublimates and *cadmia fornacum*, though in a very small quantity: these are either entirely powdery, or in tolerably compact lumps and masses, neither firm nor hard, but tender and crumbly, and easily pulverable, though in themselves not a powder, but naturally like a baked earth. Their colour is commonly a dark-grey underneath, over that a whitish grey, and the uppermost of all a yellowish white; their particles are generally quite clear, or flakey, like a tender *glimmer*; their texture very porous, spongey, and loose, consequently are extreamly light; to the touch they feel rough, stubborn, and gritty, though rubbed to a tolerably fine powder.

They

They are generally, though falsely, considered as a proper *hut-fume*, or *arsenic*, especially when they assume appearances of a grey meal: but, not to insist that experience shews quite the contrary, we may easily imagine, volatile matters, that should stand and hold out, when settled in the confines of the strongest glow of a furnace, to be something else than *arsenical*; and hence we need not wonder, they destroy neither mice, nor rats.

This zinky matter manifests itself in tall smelting furnaces, particularly in those where the operation of *crude smelting* is performed; that is, where small or poor ores, which are commonly quartzy, mock-leady, and *pyrity*, also, incidentally, somewhat *glittery*, are smelted and concentrated from a large quantity of ore, to a regulus, or cake. It takes its place in the lower parts of the furnace, particularly on the sides, having under it, for its stool, that mock-leady, stoney, and hard matter, of which hereafter.

The manner of its origination must, doubtless, be like that of *arsenic*, namely, in the way of a fume and vapour, seeing no part of it is observed to be run. When exposed long to the air and weather, it opens, that is, becomes tender and porous, and fit for making brass; the reasons of which are not proper here to be given, as I now only consider it on account of its *arsenic*. At our huts it is thrown away, and as it must be knocked and broke off the furnace, 'tis called *furnace-fragments*, by many *calamy*, though improperly, on account of its very different admixture; wherefore that appellation ought to be qualified by the epithet *calamy-furnace-fragment*, or *furnace-calamy*; nay, it should justly

be

be limited, eſpecially if we would not confound it with that I am now to ſpeak of, and from which it differs not a little. But, as is already ſaid, it contains the leaſt *arſenic* poſſible, diſcoverable upon roaſting it, rather by the noſe than by the eye; but it partakes of ſulphur in a greater proportion, as appears alſo from the roaſting, and as may eaſily be conjectured from the ground-mixtion of this zinky matter. In a word, it ſmells partly *arſenical*, partly ſulphureous; as ſulphur may, intangled in ſuch calamy admixtures, reſiſt the hotteſt glow, ſo much more may *arſenic*, which commonly yields not ſo eaſily to the fire as ſulphur does.

Underneath, and behind this, there lies, lower on the ſides of the furnace, a ſtoney, hard, heavy, black matter, not properly to be claſſed for its *arſenic*, but rather, on account of its order of place. Many a one might take it for a ſlag, or ſcoria, than which it is nothing leſs, as appears upon breaking it; ſeeing it does not appear glaſſy, ſmooth, and ſhining, as genuine ſlag does. Externally this matter is often, as it were, glazed over, but internally has a quite different appearance, namely, that, notwithſtanding its hardneſs, which indeed, in reſpect of the abovementioned calamy-furnace-fragment, is conſiderable, yet it may be ground ſmall, ſo as to become like a ſooty duſt to ſmut the hands, which ſlag never does, unleſs reduced, in the moſt careful manner, to the fineſt meal. Here and there, internally, it alſo often appears *ſlaggy*, and run; nor can it be otherwiſe, conſidering the ſtoney nature of the ores employed in the crude-ſmelting, and the fierceneſs of the fire. This effete matter contains but little *arſenic*; but taking of what is glittering, and in texture often

often appearing like a fine-grained mock-lead, we ſhall find reaſon to claſs it amongſt arſenics; nay, ſometimes it ſhews ſo like a foſſile mock-lead, and a mineraliſed body, as to impoſe on the moſt intelligent in ores. The origination of this, indeed, rather than of the preceding *calamy* matter, ſeems to be owing to a caking or running together; yet it is alſo of various ſorts, and, upon properly viewing many a ſample of it, we muſt allow it rather to be aggregated together in the way of a damp, or vapour. For, though we find amongſt it pieces, not only caked together, but quite vitrified, as may be eaſily conjectured from the running together of quartzy, eſpecially if ſomewhat leady, and thus poſſeſſed of vitrifying particles, yet the principal part is of quite another, or rather a new appearance.

It appears black and grey, flakey, and almoſt like a mock-lead, though very different, it being more kindly and light. It is not only, in ſome meaſure, of the nature of zink, or calamy, which cannot be ſaid of any one ſort of mock-lead, but contains as much, if not more *arſenic* than the meagre, lean mock lead. In a word, 'tis a kind of fly-ſtone ſublimate, riſing up entirely at the laſt, but to no very great height; which, together with its calamy and *arſenical*, or, volatile portion, has taken along with it, by the violence of the fire, ſomething of a crude, earthy, and, perhaps alſo, of a mock-leady nature, whence it happens to conſiſt of ſo coarſe a mixture, as to be uncapable of mounting high; and this is ſimply called *furnace-fragment*, as it muſt be broke off, in order to clear and fit the furnace for a new operation; a name which may ſufficiently diſtinguiſh it from the abovementioned grey, white, yellowiſh

N matter,

matter, if, for the greater perspicuity still, be added the epithets, *coarse*, *mock-leady*, and *poor*.

Now in smelting-furnaces, where the *arsenical* matter skims off, or rather evaporates from the metal designed to be procured, I know of nothing else, which, as an *arsenic* form, should here deserve a place; all to be found there, and referable hither, being either *poison-meal* and *hut-fume*, or *poison-stone*, that is, *furnace-fragment*. For the external images appearing in many places in clusters, or flakes, and the like beautiful confections on this and the other *furnace-fragment*, according to the descriptions of the ancients, and bare copyings of the moderns, are very rare with us at Friberg, nay, they are not at all observable, and are, properly, something procurable rather from actual calamy-works, than from ore-smeltings, seeing they appear in all manner of zinky flowers, and the like efflorescences, in the course of brass-making.

We are not, however, to suppose arsenic, like sulphur, to be entirely dissipated in roasting-hearths, and in furnaces, for more than a little of it fluxes in a metallic form along with any thing capable of retaining it; settling together with the metal, as in a regulus, in the fore hearth; bearing the being tapped off therewith; not mingling, 'tis true, with the metal, but parting from it, floating a-top, and bearing, after cooling a little, to be heaved off from it, like a cake. Yet, in the method of crude-working we observe, that what of it remains unvolatilised, goes into that regulus usually called *crude-stone*, without being able to appear in the above separated form; because the metal, whether lead or copper, which should, and does repel it, is not yet arrived to its due metallic body, but is still greatly

greatly intermixed with all manner of earthy foreign matters, consequently, is of a very loose, spongey texture, and hence as light, if not lighter, than arsenic itself; and that matter, wherein it principally fixes, not yet separated from the said metals.

But in the methods of *lead-working* and *black-copper-making*, it plainly appears in our smeltings, where *arsenical* ores come into the *additions*, and where *arsenic-pyrites* happen in the *crude-working*, and the *crude-stone* being, at length, duly prepared, comes into the *lead-working*, and where the copper-stone being *set*, or drawn off, comes into the copper-working; nay, is there the whole, or principal part, when the lead-working happens to employ no pure *glitter*, or lead-ore, but is intermixed with all manner of rich, chiefly *arsenical*, ores, also with actual unseparable cobaldish ores: in a word, where many sorts come together, and one working succeeds another, 'tis no wonder, if, in many places, little or no mention be found made of *speise*, *leg* *, &c.

What thus retains the *arsenic* to itself, and, in some measure at least, fixes it, so as to make it flow like a metal, and bear the being cast, is, principally, an iron-earth. I say *principally*, and this not only at our lead, but at our black-copper-workings; though particularly in these last, some admixture of copper must be allowed, and this, sometimes, is called *speise*, especially, when produced from the lead-working; sometimes *leg*, also *kupffer-leg*, when from the copper-working; it floating

* These are the several appellations of the abovementioned floating *arsenical* regulus.

and lying a-top the tapped black-copper, and from white inclining a ſmall matter to a copper reddiſh caſt. Both are of a whitiſh metallic appearance, texture, and weight, but brittle; moreover, tolerably hard, according as they are more or leſs incorporated with metallic earth; both contain from a third to a half of *arſenic*, and, as I have experienced myſelf, may alſo hold a good deal more, but ſeldom leſs; and that from incidental circumſtances, which, in the buſineſs of ſmelting, both in regard to the method of working, and to the matters themſelves, may be endleſsly variable.

Speiſe is a term uſed alſo among workers in braſs, but with the addition *glocken*, thus denoting bell-metal; a matter appearing pretty pale, though inclining more to a yellowiſh caſt, as it muſt, on account of its principal ingredient, the braſs: as to the reſt, it is harder, and more metallic than, and therefore not to be confounded with, our *butſpeiſe*. Aſſayers alſo have their *ſpeiſe*, but which they might more properly call an iron-regulus; as yielded by thoſe *pyrites* which contain no copper, and remains further unexamined by them, ſeeing they look for nothing elſe in *pyrites*, but ſilver and copper, conſequently is unknown to, and thrown away by them, under an appellation borrowed from ſome colour or other, and which, in ſome meaſure, ſerves as a ſcreen for their ignorance. Now, 'tis true, there are ſome *pyrites*, whoſe iron-earth is *arſenicated*, as the white, entirely; many of the yellowiſh, conſiderably; and thus, in aſſaying, there ariſe ſuch *reguli*, as aſſayers may, on the ſame foot with ſmelters, call *ſpeiſe*; but as ſome of them afford only a very ſmall matter of, or no arſenic at all, 'tis wrong to bring them under one common appellation, *ſpeiſe*.

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In the *arsenic-huts*, which are chambers where the *arsenic* is refined and purified, *arsenic* again exhibits the appearance of a fine meal, or of a crystalline body; both ways, sometimes of a white, sometimes of a yellow, sometimes of an orange cast: yet it ought not to be distinguished so much by being a meal, or powder, and a fluxed body, as by the variety of its colours; for the powder is convertible to a crystalline body, and this last may be reduced again by a heedful sublimation, to a meal, and the meal again converted to fly-stone. Now, as the meal, either yellow or white, turns mostly, nay, wholly to a crystalline body, we shall here the rather treat of the crystalline form of *arsenic*; and as the yellow and orange colours remarkably differ from the white, we must say something to three sorts of *arsenics*, namely, *white*, *yellow*, and *red*.

Arsenicum crystallinum album, white crystalline *arsenic*, is a white, considerably ponderous, fluxed, glassy, transparent body, brought to that form by means of pot-ash and sublimation. The pot-ash principally serves for purifying, or for, at least, retaining and consuming that fuliginous matter lodged in the *arsenic*, and which makes it of a greyish cast; be such matter only from an inflammable earth, or, as it also sometimes happens, from sulphur itself. Whether it have any other effect thereon, must be learned from a careful examination, made expresly, both of this crystalline *arsenic*, and the crude *arsenic-meal*, and from a candid comparison of the several proofs made, the separate consideration of which would here carry me too far.

In order, however, to discover the genuine proper nature of this smutting substance, I have, as supposing it to be a fat, inflammable earth, digested the white crystalline *arsenic*, after rubbing it fine, along with inflammable matters, as expressed oil of almonds, and by sublimation procured a quite dark-grey sublimate. Again, treating it in the same manner with iron-filings, by this means, along with some white crystalline flowers, I have obtained a dark-grey *arsenic*; so that the black matter arising along with the *arsenic* from *arsenical pyrites*, is to be ascribed to an iron-earth; especially as it is otherwise evident, that no *arsenical pyrites* is without it.

I also found quicksilver alone capable of withholding this blackness, and also the yellowness of yellow *arsenic*, and of raising the *arsenic* alone in beautiful white crystals; a circumstance, sure, worth no small degree of attention. It is pretty heavy, nay, to a degree of making it suspected of containing something metallic, even should it be unknown in its native form; it is partly transparent as glass, partly of a milky colour; and what was transparent, in time, loses that quality, becoming externally, also, of a milky colour, particularly by means of the free access of the moist air; nevertheless, it continues sparkling or shining, and, against the light, if newly broke, with its shivers, appears smooth, and internally transparent; but, by degrees, it loses all its transparency, and that sooner or later, according to the size of the pieces or shivers, and the nature of the place they are in; 'till at last, still retaining its splendor, and without falling, or turning to a powder, it becomes throughout of as milky a colour

lour as a white smalt, usually employed in enamelling; and, to my mind, almost such another mass as that arising from running alum and common salt together, for the preparation of Glauber's salt.

Whether it be a real salt, I shall as little dispute as believe, seeing it does not partake of the genuine properties of a salt, being neither soluble in water, nor peculiarly affecting the tongue: the truest conception we can form thereof, consists in considering it a calcined metallic body; as, in its origin, it exhibits a metallic body, which is here only a little disguised, but again recoverable upon the addition of the metallic portion, which happened to be burnt out. In the course of the refining, it rises like a white fume, and settles, at first, as a white powder, which, as the heat gradually encreases, 'till the subliming vessel be made of a thorough glow, cakes and runs to a close, glassy body.

Arsenicum *crystallinum flavum*, yellow crystalline *arsenic*, is, in its principles, nothing else but the above white sort, and in the very same manner brought to that form; only that some sulphur happens to stain its beautiful milky colour with a cast of yellow; and though, properly, not so transparent as a fresh white sort, yet, in its substance, it is shining and glassy, like a yellow smalt, or enamel, though by far more beautiful.

Arsenicum *rubrum*, red *arsenic*, differs from the yellow only in being more richly dosed with sulphur, and, consequently, has a greater degree of opacity, and a less glassy appearance; for the rest, 'tis an *arsenic* in ground, and popularly called *sandarach*;

darach; yet, under a proper encheiresis, or treatment, it often turns out as beautifully transparent as any ruby, only its redness inclines more to an orange, whence it is sometimes called *sulphur-ruby* *. If it degenerates to a brown-red, it has either stood too long in the fire, or got some foreign admixture along with it, either by accident, or with design, as may be seen from the *lapis de tribus*, where the metallic, antimonial portion must needs sully it; yet this brown-red tint is often no impediment to its transparency, when held to the light in thin pieces.

It is brought over, like sulphur, by a distillation, from retorts into receivers, rather than by a sublimation, and this is the very reason of its opacity; for, if you force off only a little of it again in a glass body by a strong sand-heat, so as to melt in the neck, it runs down in clear drops, appearing like a red glass. It is certain, *arsenic* greatly affects the sulphur found here, and must therefore impart the colour; and no way has hitherto been hit on, I will not say, of separating it entirely, which is impossible, but of separating even the greatest part of it; and yet some of it must go off, partly of itself, by the softest degree of fire, for sulphur mounts easier than *arsenic*, though this succeeds not with the yellow crystalline *arsenic*; partly through the addition of a separating medium, or matter, which sulphur more affects, for instance, quicksilver: when the *arsenic* happens to rise white separately, and settle higher up, the quicksilver, which cannot rise so high, settling lower down, as a grey sublimate along with the sulphur.

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* Rubinus sulphuris, item, rubinus arsenici.

Moreover, as sulphur appropriates the quicksilver to itself, and quits the *arsenic*, so it keeps in a juster proportion with the former, than with the latter; it, in one case, bearing more and less, almost in the proportion of the dose given, whatever that be; and in the other, being incapable of receiving either more or less, the proportion being constant, a circumstance worthy of notice.

Red *arsenic*, or *sandarach*, may be made from pure ore, and such *pyrites* alone, wherein the sulphur and arsenic are together in a sufficient quantity; or from *pyrites-additions*, or dosings, so that the one shall supply what the other wants; or from poison-meal and *sulphur-pyrites*; or from *arsenic-pyrites* and sulphur-slags, that is, the *arsenical* sulphureous residue procured from crude sulphur: but the attempting to make it from white crystalline *arsenic* and actual sulphur, either does not succeed at all, or with great difficulty: whence appears, (1.) the somewhat coy or repelling nature of the white crystalline *arsenic*; (2.) how much the chemical combinations depend on the appropriations, congruencies, or aptitudes, also on the diversity of the matters, when employed in their unprepared and native state, directly from their matrices and natural admixtures; so that red *arsenic* is not a thing, in its ground-substance or principles, distinguishable from the white, as some falsely imagine.

Thus we have exhibited *arsenic* in all its various appearances, from its first fly-stone state, to that wherein 'tis fitted for common use, and thus from the huts to the shops: and not only so, but we here teach how to reduce it back again to all the forms it had before undergone; in particular, to i s

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first, native, reguline, semi-metallic state, so as to prove more beautiful than it originally was; as thus: take finely pounded white crystalline *arsenic*, and mix it, either with the black flux, or with salt-petre and tartar, in the usual manner of making regulus of antimony, and letting it duly run in the wind-furnace, you then procure a compleat, beautiful regulus of *arsenic*; yet, little or none at all, if either you let the crucible stand too long, or give too brisk a fire: but if you miscarry in this, take iron in aid, and proceed in the usual method of preparing the martial regulus of antimony, and the *arsenic* will be sufficiently fixed. Only, by this last method it proves impure, from having swallowed up a great deal of iron, as appears from the analysis; it is, however, the greatest part *arsenic*, which may easily again be made to fume from it. It generally appears like a *speise*, with which it also greatly agrees, and, upon adding some copper to it, it turns of a reddish cast, nay, becomes the very *mixtion* of the above described *kupffer-leg*, nay, even *kupffer-nickel*.

I shall further only suggest, that *hut-fume* corrodes the very window-panes of the huts, turning them of a milk-colour, and rendering them dim and opake, and thus it finds, as it were, a magnet in them. Again, that with lead it vitrifies exceedingly easy; and the glass thus procured proves extremely useful in *incoctions*, as it forces stubborn and unkindly ores, with this circumstance attending, that this highest of combinations, which is even performable in close vessels, is an uncommon and almost incredible instance in the business of vitrification: and this, in my opinion, affords, if not the principal, yet not the least considerable reason, why *misspickel*, when its *arsenic*, in the operation of

crude-

crude-working, happens to corrode, vitrify, and thus easily carry off the lead among the scoriæ, at least from the *glitter*-eyes always intermixed, is considered as rapacious and unkindly.

To recapitulate briefly; *arsenic*, by means of art, shews itself either a volatile, flakey, semi-metallic, or a reguline body, which is a factitious *fly-stone*; or a grey, white, and yellow powder, and then it is called *hut-fume*; or a *furnace-fragment* (cadmia fornacum); or a *speise*, or a kind of glassy body, and then 'tis a white and yellow crystalline *arsenic*; or a red *arsenic*, that is, *sandarach*; or again, a semi-metal, and a regulus.

Here I must not omit explicitly mentioning a matter I only incidentally touched on above, as being, in some cases, entangled with *arsenic*, and this is *zink*, which lodges both in fossile and factitious calamy.

Zink, or *spelter*, cannot better be described or conceived than by saying, that it is that matter which makes or tinges copper yellow, an effect to be affirmed of no other thing in nature besides. *Zink*, so far as is hitherto known, is, principally, in three forms; (1.) in that semi-metallic, reguline form, properly called *zink*, or *spelter*; (2.) in an earthy, or rather stoney form, namely, in the fossile calamy, or *lapis calaminaris*; (3.) in flowers and sublimates, in particular, in the above described white-yellowish tender *furnace-fragments*. Genuine formal *zink*, also called *contrefait*, is a semi-metal, externally like lead, yet something brighter, internally shining like a mirror; not very brittle, like a bismuth or regulus, and yet not very malleable; altogether as inflammable as a sulphur; when it changes

changes to a white spongy froth and wool, a *philosophical cotton*.

It turns copper not only of a higher yellow, whence the metal happens to be distinguished by the appellation, *prince's-metal*, or rather *bronze-metal*, at least with us Germans, but it also renders it more brittle than the fossil calamy does; hence, I suppose the proper tinging substance, which in the fossile calamy is blended with an earth, something adventitious and foreign, not entering along with the tinging parts into the body of the metal, is incorporated in another metallic brittle-making substance, namely, lead.

For, (1.) the sort of ore at the Hartz, whence our *zink* is derived, is never without lead-ore, nay, is principally found to consist therein; (2.) from fossile calamy (for which end I have employed the Spanish) and *lead-glitter*, I have produced a formal beautiful *zink*, which, in any other method, would not succeed, at least not with me. Nay, it is no uncommon thing to find calamy and *leadglitter* together in a vein, a sample of which I can shew from Brilon in Westphalia: and it will be plain from considering but a little attentively, the loamy earth near Ulkos in Poland, wherein lead-ore lies irregularly huddled together, to which might be added other circumstances; that there is something separable from the *zink*, which is not indeed pure lead, tho' approaching nearer to lead than to *zink*.

As I am perswaded that this tinging substance is lodged in other earths and stones, besides that called calamy, at the brass-huts, so there are also other metals, besides lead, out of which it may be educed; at least I have found, upon working tin along with a cer-

a certain ore, without any the least addition of calamy, if not a real corporal *zink*, yet its proximate infallible sign, the genuine *philosophical wool*. But without any such experience, and from a slight knowledge of metallic bodies, the derivation from lead to tin is easy; but then in the fire this production is extremely dissipable, *zink* burning away as quickly as it is produced, so that it is not procurable in our huts in its living state; not from a defect of the proper matter for the purpose, as we may have such in *furnace-fragments*; but then it is no longer to be catched *living* (from the following circumstances, namely, the degree of the fire, the nature of the furnaces and *additions*, and the inexperience of the operator) but *dead*, and in its ashes, from which, indeed, it is again recoverable *.

Formal *zink*, fossil *calamy*, and *furnace-fragments*, or *cadmia fornacum*, appearing so different bodies, who could imagine these three should be possessed of

* *Pott*, in his dissertation on *zink*, makes zink to arise from the metallisation of an alkaline earth, whence he deduces its solubility in acids, and that it consists of a mercurial, vitrescible, and a tender inflammable earth; the mercurial earth appearing from its flowing in the fire, its commixtion with mercury, and its mercurification; the inflammable earth, from its ready ascension, when treated *per se* in the fire, as also from its fulmination with nitre; its vitrescible earth, from its vitrescency, which Henckel first accomplished in the vehement heat of a wind-furnace. But its specific nature, and mixtion, he makes to consist principally in the indeterminable, and scarce perfectly imitable combination of a copious inflammable principle, along with a certain peculiarly alcaline earth: and to this earth is owing both its difficulty of vitrescency (such as is also observable in tin) superable only by a most vehement degree of fire, and the usual bitterness of calcarious earths in solutions; and if, by means of the inflammable earth, it changes to a reguline body, is the cause also why copper changes to a yellow colour.

of one and the same virtue, or have one and the same *materia prima*, to tinge copper withal! or, who could think it possible to educe such a matter from tin, without any addition of calamy, *zink*, and *cadmia fornacum?* Here I cannot omit transcribing Lohneiss's * account, a considerable metallurgist of the *Hartz*, from which place alone *zink* comes to us: and though we might expect from him the best account of it, yet it happens to be concise enough, and something fuller and more explicit, both on the origin of *zink*, and on the *Rammelsberg* ores, fit for the purpose, were to be wished for. 'In the course of the smelting, (says 'he) a sort of metal, there called *zink*, or *Contre-'fait*, collects below in the chinks of the fore-wall, 'or breast of the furnace, where not covered thick 'over, between the shiver, or slate, of which it is 'built. Upon knocking on the wall, this metal, 'which is white, like tin, yet harder, and more 'malleable, and tingling like a little bell, runs out 'into a trough placed underneath. The quantity 'procured at a time is in proportion to the care 'employed in collecting it. They sometimes get 'to the quantity of two pounds, at other times, 'not quite three or four loths.'

Fossile calamy, *lapis calaminaris*, called also *cadmia fossilis*; under which last appellation we must not include the cadmia called *cobald*, yielding smalt; and which by way of distinction, both from that other cadmia, and other cobaldish, namely, arsenical ores, is called *cadmia pro cæruleo*. *Calamy* is a stone, or often a sort of stoney earth only, sometimes yellowish, sometimes brown, and sometimes a brown red; not only as it comes to us from other countries,

* Berg-buch, p. 83.

countries, as Poland, Hungary, Spain, and the Indies, but as it is also found in several parts of Germany, as Bohemia, Franconia, and Westphalia. The heavier it is, it imparts the more a greater increase in weight, and a higher tint to the copper. It affects a loamy, claiey, fat bottom, and such earths have even properties, manifesting a no small degree of affinity with *calamy*; it therefore lies not very deep, its mother-earth appearing commonly just under the turf, nay, constituting the uppermost layer, as at Tscheren, near Commodau, in Bohemia, where it may be taken up at the *day*. This Bohemian sort yields (1.) an iron-vitriol, as an actual iron-stone also *breaks* amongst it; (2.) alum, a famous alum-work lying near the above place; and, I doubt not, but all *calamy-stone* in general do the like; but if you give it copper, a great part of the earth of the *calamy* incorporates with it, and assumes a metallic form and property; from hence it may be known, that brass, into which about a third of its earth is introduced, will endure the being worked like any fine copper.

Calamy furnace-fragment, or *cadmia fornacum*, I have already considered, so far as it included *arsenical* particles; but must here again take it up, because its nature and effects are entirely *zinky*.

Hither is chiefly referable what with us not only hangs in the upper parts of the furnace, but which also looks bright, particularly yellow and whitish, being tender, and not run together; also what settles externally over the fore-wall or breast of the furnace, between the chinks or openings of the stone, and the whole of that lower, mock-leady, flaggy, crude-stoney, caked matter, which, in the course of working the furnace, being still soft, is

beat

beat out with an iron, and called *sweep*. From the lead-working, to which are taken, together with the *crude-stone*, and the *glitter-ores*, the burnt rich silver-ores, little or nothing is procured; as most ores, both the smallest or poorest sort, have, by the operation of crude-working, and the rich ores, by that of *roasting*, already lost their aptitude for, and virtue of yielding *zink*: besides, the *glittery* or lead-ores being, with us at Friberg, not in any considerable quantity, they cannot, without the evaporation of these last, exhibit those zinky flowers they might otherwise contribute to ripen.

Were I to pick out, among the many ores and minerals, that come into the operation of *crude-working*, those that contribute to form this zinky furnace-fragment, I would take the *glitter* and *pyrites* together; from the former I could derive the body, from the latter, the soul, and say, that the sulphur and lead are become incorporated and animated by a peculiar appropriation and aptitude, and a number of unimaginable incidents, such as easily happen in the large way of working, though not in the small way of proof.

What the nature of this furnace-fragment, or *cadmia-fornacum*, at the smelting-houses of the Hartz, is, I know not; but referring the reader to Lohneiss, shall only relate the success of an experiment tried on Friberg *cadmia-fornacum* for brass; for this purpose, I roasted, after rubbing, the calamy under the muffle very small, 'till it no longer smelt of *arsenic*: I took the sort that, being longest exposed to the air and weather, was become tender, or opened, as they speak at the huts, this being esteemed the best sort, though for what reason I cannot imagine. After being well roasted, I mixed it

it with coal-duſt, in the ſame manner as is done at the braſs-works for foſſil calamy, and with this mixture I doſed the copper in the crucible, and by letting the whole flux, or run well together, procured a braſs like any other braſs, excepting that it is ſomewhat more brittle, though it may bear being drawn into wire as far as nº 15.

Among this furnace-calamy, forwards in the chinks of the furnace, about and over its breaſt, there is a ſpongy, woolly, white powder, but in ſmall quantity, uſually called at our houſes *but-nothing*, alſo ſimply, *nothing*, or *nihilum*, which is the very ſame I mentioned above under the claſs of calamy flowers, as ſomewhat indeed *zinky*, yet likewiſe a little *arſenical*, and to be diſtinguiſhed from the proper *arſenic*-meal, called alſo *but-nothing*, which commonly mounts higher. The genuine *arſenical but-fume* is a noxious thing, not deſerving the name of that innocent drying matter, uſed for the eyes. *Nothing*, or *nihilum*, is an appellation in uſe alſo among druggiſts and apothecaries; and the celebrated M. Lincke, apothecary at Leipſic, informs me, our modern *nihilum* in the ſhops is only a tender, foſſil, white earth, or marl, *marga foſſilis*; and ſuch I myſelf have hitherto found it: ſo that it is highly neceſſary, on many accounts, druggiſts ſhould be ſubject to a viſitation and inſpection, equally with, if not rather than, apothecaries, as the latter are always ſupplied by the former with their drugs. Further, this ſhop-*nihilum* appears to me to be a kind of calx, or lime; M. Erhard, of Memmingen, informing me, that ſome apothecaries in Suabia burn ſpad to a lime, and ſell it in large quantities to the druggiſts of Nuremberg and Francfort, under the name *Nihilum*. *Nihilum*, or *nothing*, was, doubtleſs, formerly, among

O druggiſts

druggists and physicians, only a calx, or flowers of burnt calamy-stone and zink, or the woolly, white, tender powder, arising and collected from the preparation of calamy or zink, for brass or bronze-metal, or barely with this intention, and thus quite free both from *arsenic*, or other foreign admixture; as Pomet, an author deserving more credit and commendation than most writers on natural history, has truly hinted. Hither again may be referred the abovementioned *nihilum* from smelting huts, after culling and thoroughly burning it, in order to purge it from the *arsenic*, though scarce equalling the other in tenderness and purity: yet neither are calamy, nor zink flowers, and a fossil marl, one and the same in nature and effects: nor again, are marls one and the same, as I once found a sort, sold for a *nihilum*, to be *arsenical*.

Pomet writes as follows: '*Pompholyx*, white *calamy*, white *nothing*, and *ore-flowers*, erroneously 'called *metal-ash*, is what adheres, in the course of 'smelting for brass, to the cover of the crucible, 'and the smelter's forceps; for, it is certain, that 'neither bell-metal, nor the *metal*, nor the *potin* '(a kind of brass whereof pots are often made) but 'brass alone, yield the genuine *nihilum*, though 'most writers have thought otherwise; there being 'naturally nothing besides brass, or yellow copper, 'that yields the white calamy, or *pompholyx*. But 'though *pompholyx* may be easily found, yet no 'one thing, either through the ignorance or negli-'gence of apothecaries, is more unknown; in re-'gard most of them are of the opinion, *pompholyx* 'and tutty, having one and the same virtue, may 'be substituted the one for the other. The most 'beautiful *pompholyx* comes from Holland; not 'that it is really a better sort, but only on account

'of

'of its being collected in a cleaner manner. You 'must chuse that sort which is beautifully white and 'light, and will bear rubbing easily, and clean, *&c.* 'Bell-founders may, indeed, collect a little of it, but 'so very little, and besides, not very pure, that it 'scarce deserves notice. The bell-founder, by 'whom I saw *pompholyx* made, assured me, he ne-'ver sold it but to particular persons, who came 'and begged a drachm of him, to put into wine, as 'a drink in a fever; at the same time averring it 'to be an infallible remedy in that case; but I ne-'ver tried it, nor would I advise it to any body 'else, *&c.*'

Besides this *nihilum*, there is another form, wherein zink lies concealed, namely, *tutia*, an Arabic, at least an oriental term; the reason of which is as little understood, as why calamy-flowers come to be called *nil*. It might originally have denoted a kind of drying, astringent plant, as the plant *turbith*, the *spodium*, or ashes of bones and plants, have been denominated from minerals, having, in use and virtue, something in common with, or resembling such vegetable or animal parts. In like manner the term *tutia* was introduced into the mineral kingdom; and as we had this commodity originally from Alexandria, it was called *Alexandrina*, as it still is at this day, from what part soever it comes. This appellation, 'tis true, is unknown in our smelting-huts, and consequently does not cause that confusion we experience from the term *but-nothing*. Now though we are directed by all the writers on the subject to the brass-huts, and workers in brass, yet I am at a loss to conceive how this *tutia* can differ from the *calamy-nil*, as both of them arise in the making and smelting of brass. *Nil* is calamy-flowers and a white powder; *tutia* appears like dark-

grey ſhells and rinds, and is alſo derived from calamy, but in appearance they greatly differ, which muſt be owing to different circumſtances and cauſes, of which I am entirely ignorant, and of which no explicit account is any where given. Here again, we give Pomet's deſcription of the *tutia* the preference to that of any other writer.

'The *tutia*, ſays he, denominated *Alexandrina*, alſo *ſpodium Græcorum*, is a metallic ſpecies, 'formed like ſcales or gutters (or rather, happens 'to be ſo formed) of different ſizes and thickneſſes, internally even and ſmooth, but externally 'like a ſhagreen, being beſet all round with grains 'of the ſize of pin-heads, whence it had the name '*tutia botrytes*. The *tutia* ſold in France comes 'from Germany' (alſo from Sweden, according to Lemery, in his dictionary of drugs) 'where it 'is prepared from braſs. We muſt not imagine, notwithſtanding its being affirmed by almoſt all ancient and modern writers, that *tutia* is derived 'from yellow copper, and ariſes at the ſame time 'with the *pompholyx*; this is falſe, the *tutia* adhering to the earthen cylinders, or rollers, ſuſpended in braſiers furnaces, for the purpoſe of 'catching the fume of the metal, whence the *tutia* 'has its ſhell or gutter-like form, and ſome of the 'pieces have earth ſtill ſticking to them. 'Tis externally of a beautiful mouſe colour, and internally of a white yellowiſh caſt, not eaſily broke 'to pieces', &c.

Here we have the form of our *tutia* plainly enough deſcribed, only the reader is not to ſtumble at our author's making a diſtinction between braſs and yellow copper, and allowing the *tutia* to be derived from the former, and not from the latter; whereas braſs and yellow

yellow copper are, with us, held to be one and the ſame thing, but among the French, the latter is made from formal zink, and ſuch yields no *tutia*; and as there is but little of it prepared, there muſt be but little demand for it: nor, at our author's ſaying, that *the tutia ariſes not at the ſame time with the pompholyx*; for, be this as it will, the *tutia* is derived from the very ſame principles with the *pompholyx*, namely, calamy, and tinges copper yellow. In ſhort, *tutia*, *nihilum*, *cadmia fornacum*, *foſſile calamy*, and formal zink itſelf, agree entirely in principles, though they differ in form and accidental appearance.

This digreſſion from *arſenic* to zink, cannot be thought diſpleaſing to the reader, ſeeing they are the effect of one operation, and, conſequently, have an affinity with each other; and, upon rightly taking the matter, the *pyrites*, either from its ſulphur or *arſenic*, aſſiſts to the production of zink: nay, it may be queried, whether, as Charras pretended, a zink may not be made from *arſenic*. Beſides, I wanted to clear up a ſet of names, ſometimes applied to one thing, ſometimes to another.

Arſenic, *orpiment*, *realgar*, and *ſandaraca*, ſtand for things, which if not entirely *arſenical*, generally partake conſiderably of it. *Orpiment* is a ſulphur-yellow, flakey, *arſenical* mineral, of which painters, with the aid of indigo, uſually compoſe a green. *Realgar* is an unknown term, with ſome denoting the ſame thing as *arſenicum cryſtallinum flavum*; with others, *arſenicum rubrum*, or the common ſandarach; yet it always means ſomething in which the *arſenic* is the principal part, and the ſulphur, which, in both the red and yellow, makes

the diſtinction, is, in the former, ſomewhat more, and in the latter, ſomewhat leſs in quantity. *Sandaraca*, properly denoting a gum, or roſin, is here alſo applied to a mineral, which is, or appears to be gummy, or fatty. Now, 'tis true, genuine ſulphur is of ſuch a nature and form, but by it this laſt is not meant, but ſomething arſenical, only combined with ſulphur; and, in ſhort, ſuch a body as, be it white, yellow, or red *arſenic*, may, both by a lixivial and acid ſalt, (which is ſomething very extraordinary) in particular by ſpirit of nitre, be changed into a formal gum.

We are, in the next place, to enquire into the origin of *arſenic*, or whence it is derived. And (1.) 'tis found in the earth ſo pure and ſnow-white, as ſcarce to be rendered more ſo by art; but this is a very rare caſe. So far as I have been able to judge from circumſtances, it may lie unobſerved by coarſe veins, conſiſting of *pyrites*, *miſſpickel*, *mock-lead*, and *glitter*; yet the *arſenic-pyrites* commonly, and in large quantities, *breaks* among them, and chiefly contains the *arſenic*. At Friberg we know nothing of this *arſenic*, the ſamples I have either ſeen, or actually had in my poſſeſſion, being only from the mines of Joachimſthal, in Bohemia, where the veins conſiſt, together with *red-goldiſh* ore, both of the ſmalt-cobald, and that other black *arſenic*-ore, of which more by and by, uſually called *cobald*, but really a kind of pure fly-ſtone, or ſooty *arſenic*.

Whether this white, foſſile *arſenic* be an original production, whoſe particles, before thus exhibited, were not *arſenic*, but firſt became ſuch in the exhibition; or rather, whether its origination conſiſts only in a ſeparation from another body, wherein indeed

indeed it cannot have lain as a ſnow-white powder, yet as a formal *arſenic* in an ore form; as neither ſulphur is made from *pyrites*, nor quickſilver from cinnabar, but both of them ſeparated from theſe bodies, is a queſtion that has ſome difficulty? The firſt is not impoſſible, ſimple bodies firſt uſually ſeparating from mixts or compounds; yet the ſecond is the more probable, as the black *arſenic*-ore, conſequently, what is prepared to hand, is not combined with any coarſe, fixed earth, to unfit it for ſuch a degree of fining and whiteneſs; not to mention the genuine ſmalt-cobald, which often, in certain circumſtances, is ſeen diſſolveable both in the upper and lower *weatherings*, a circumſtance never obſerved in a *miſſpickel* or *arſenic-pyrites*, however long expoſed, as I myſelf have remarked, in all manner of air.

What makes this ſpontaneous purification of the *arſenic* a difficult matter to be credited, is the prejudice entertained, that the action of the fire is abſolutely neceſſary for that purpoſe; though nothing is more evident than the ſpontaneous reſolution and vitrioliſation of the *pyrites*: and at Wenſeen, in the territory of Lauenſtein, in the Electorate of Hanover, a beautiful, tranſparent, yellow ſulphur *breaks*, beſides in ſeveral parts in Hungary, without the action of any obſervable fire; and the mercurification of metals, or rather their ores, is no other way to be fundamentally laid, than by gentle macerations, with appropriated ſalts and ſaline waters, and by the action of the inſipid, powerful body of the air.

(2.) *Arſenic* is alſo often found in the earth perfectly native, without any other admixture, yet in a different form; I mean a ſemi-metallic fly-ſtone

form. This ore generally looks externally of a dark-grey, and ſometimes quite black; yet, upon breaking, it appears of a bright, metallic, leady colour; but upon lying expoſed for a while in the air, is again overcaſt with the ſame blackneſs as before. Externally it ſeems like *teſtaceous cobald*, as if made up of ſhells laid one over the other; yet, internally, theſe run all into one another, without further diſtinction of layers. Some alſo call it *cobald* and *teſtaceous cobald*, eſpecially miners, who call every thing cobald, that is either poiſonous, or with which they are unacquainted; though the more cautious and diſtinct appellation would be, *black poiſon-ore*, foſſile *fly-ſtone*, or even *foſſile black arſenic*: for, in its genuine *mixtion*, without any other mineral adhering to, or interſperſed with it, it is not only entirely fugitive, not leaving the leaſt fixed earth behind, but in the fire it exhibits altogether the ſame appearance as the factitious fly-ſtone from *miſſpickel*.

It was formerly dug for at a certain Miſnian *arſenic*-work near Schwartzenberg, and the Joachimſthal, in Bohemia, is remarkable for it; and it is ſaid to be no ſtranger at Johan-Georgen-Stadt and Ehrenfriderſdorff in Miſnia, where the beautiful, tranſparent, *red goldiſh* ore *breaks*. The circumſtance, namely, that ſuch *red-goldiſh* ore affects, or is affected by this poiſon-ore, muſt yield no deſpicable hints to diligent enquirers into nature; though I would be far from affirming the *red-goldiſh* ore to be produced from it: but here let the proper caution be made uſe of which a careful one ſhould ever keep in his eye, when, for avoiding fallacious concluſions, he would judge of the origination of two ſorts of ores, lying near, or entangled in each other.

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As one or other circumſtance might eaſily miſlead us to a falſe concluſion; for inſtance, that this *red-goldiſh* ore is highly, nay, I had almoſt ſaid, allowing for its ſilver contents, entirely *arſenical*, and not ſulphureous: further, that another ſilver-ore, as the *glaſſy*, which has only ſulphur, and no *arſenic* for its mineraliſing cauſe, is, however, not to be found there; (unleſs it ſhould happen to be conveyed thither, as things the moſt foreign may, from other veins) whereas otherwiſe it is not uncommon for *red goldiſh* and *glaſſy* ores, readily to lie near, and to be entangled in each other: moreover, that otherwiſe no ſulphur-ore is found there; omitting other circumſtances which might be mentioned; as, that the *red-goldiſh* lodge in this poiſon-ore as ſo many kernells in their ſhells. This, however, I muſt here ſay for *arſenic* (not out of any alchemical views, but only in regard to its univerſal treatment in ore-ſmeltings, and the like, and from ſome experience I have had of it) that it wants not a great deal to become a ſilver.

(3.) *Arſenic* may be ſuppoſed both to lodge in, and to be actually educed from foſſile ſandarach; as it is certain, ſandarach conſiſts of that and ſome ſulphur. This mineral is alſo found in the foſſile orpiment, partly kidney-wiſe, partly as ſo many fibres, alſo ſeparately in fiſſures in the barren rock, as I have had it out of the ſulphur-grooves, both from Cremnitz in Hungary, and from Turkey, likewiſe from Frantz-Coronzay, near Tobagá, by Neuſohl, in Hungary; affording the ſame hints to the enquirer, with reſpect to its origination, as were above given for the foſſile white *arſenic*. Now both ſorts, 'tis true, eſpecially the ſecond, are things very rare and uncommon in mineral collections; and I dare affirm, a perſon intelligent in the nature

nature and encheiresis of *arsenic*, may in this same native sandarach, hit upon something to his purpose. The means of separating the *arsenic* from its adhering sulphur, and thus exhibiting it pure, is to add something, to which the sulphur more readily fastens; whereby it will let go the *arsenic*. This is the foundation of all separations, and what gives a hint for finding out other means to the same end, that would otherwise remain unknown.

(4.) *Arsenic* is found almost in all, or at least most ores; sometimes only incidentally, sometimes essentially: in such manner, that besides its little or no other fugitive substance, capable of reducing metals to their ore state, which sulphur and arsenic alone effect, can be shewn from ores; incidentally it lodges in almost all *sulphur-pyrites*, as may certainly be concluded from the desulphuration of the purest sort; from the never-failing grey colour of crude sulphur; and from the sandarach, tho' small in quantity, procured from fining such crude sulphur; though some sorts of *pyrites*, particularly the round, yet that not always, stand excepted. The *copper-pyrites* and copper-ores contain somewhat more of it, and the richer in it, the richer they prove in copper, and the poorer, the less copper they afford: and by my experiments, none is procurable from them when they are purely martial; and in a sort of copper-ores, looking almost like a white *pyrites*, in the volatile part the *arsenic* is the principal; whence also the white colour arises; whereas otherwise in *copper pyrites* and ores, the sulphur generally predominates.

In the *lead-glitter*, the lead has left but very little room for it, being almost all of it, enveloped in pure sulphur. On the contrary, *arsenic* lodges essentially

ſentially in the *red-goldiſh* ore, as appears by the ſmell in roaſting, by the poiſon-meal procured in ſublimation, alſo from its relation to iron: ſeeing it does not part from, but rather runs together with it into a cake, without letting fall the ſilver, like as a *ſulphurated* ſilver does; for inſtance, the glaſſy ore, after the manner of an antimony. And here it is worth remarking, that the *red-goldiſh* ore uſually manifeſts itſelf in the fire no other than as a ſpad, by its ſtarting and ſpringing.

Arſenic lodges in *white-goldiſh* ore, *fallow* ore, *fallow-copper* and white ores: the firſt, on the ſcore of its ſilver-yield, belongs to the claſs of ſilver ores; the others, on account of their copper-yield, to that of copper-ores.

Arſenic in the *cobalds*, from which the ſmalt is prepared, and in the *kupffer-nickels*, which are allied to cobalds, is all in all, as not to exhibit the leaſt ſulphur, as ſuch. The finer tin-ores, called *zinn-graupen* (not the coarſer, called *zwitter*, ſuch a mixed maſs being never without *arſenic-pyrites*, *wolfram*, &c. and yielding with us the greateſt quantity of *arſenic-meal* for the *arſenic-huts*) beſide their metal, conſiſt of nothing elſe.

There are alſo *arſenical* lutes, clays, or marl-earths; as here in the *Herrn-grund* at the *Beſchert-gluck*. In ſtone I have not hitherto diſcovered any, but, I cannot ſay, I ever examined them with that view, tho' I have often for ſulphur. In water we may rather expect to find ſulphur than *arſenic*; yet there are inſtances of *arſenic*'s inſinuating into mineral waters; and it may, by art, be incorporated with water, in conjunction with ſulphur and vitriol,

triol, without which it cannot; as I have ſhewn from the *Friberg-ſchlacken-bade* *.

(5.) *Arſenic* lodges in *pyrites*, and eſſentially in the white ſort. This *pyrites*, and the ſmalt-cobald, are here at *Friberg* the principal ſorts; the former is a whitiſh ſort, conſiſting of iron, a crude earth and *arſenic*; not ſo readily found as the other ſorts, and never under the under-turf earth, nor readily in ſquats, but commonly in veins. At *Friberg* in particular, it *breaks* near coarſe veins, as mock-lead, ſulphur, copper-*pyrites* and *glitter*; particulary, it every where accompanies mock-lead: in the *Obergeburg* it readily lies near *Zwitter:* beſides iron, it contains but a very inconſiderable ſhare of ſilver; it is picked out from among our ores, as being not only unſerviceable in our ſmeltings, but alſo rapacious, or detrimental to the procuring the full yield of metal; its *arſenic*, if not well diſcharged at firſt, manifeſting its ill effects not only in the lead and copper works, but alſo in the buſineſs of cupellation, beſides proving prejudicial to the litharge. It is uſually employed for making *arſenic*, tho' only incidentally with us, on the ſcore of the charges. The *arſenic* riſes out of it, and cobald, like a white-grey fume, ſettling like a white-grey powder in the receptacles prepared for it, as in ſo many aludels. The proportion of *arſenic* in ſuch *pyrites* is generally a third, and rather over than under: and thus, it exceeds the proportion of ſulphur in the *ſulphur-pyrites*, which at moſt amounts but to a fourth of the other conſtituent parts: and theſe proportions are the more to be remarked, as they do not offer only in a few inſtances, but are obſerved to hold conſtantly.

* Breſlaw Collection, P. 9.

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We shall now consider the properties of *arsenic*, or rather its ore; (1.) In the earth. (2.) Air. (3.) Fire.

(1.) Its bed in the earth we have already considered; only this circumstance is to be added, in which it differs from the *sulphur-pyrites*; *viz.* that it always *breaks* near other ores; and only in fissures and veins, never in *nests*, as the *sulphur-pyrites*. The *white-pyrites* does not dissolve, crumble, vitriolise, or in the language of miners, become *weathered*, as the yellowish and yellow do, especially the first; for (1.) it contains no acid salt, as sulphur does, capable of exerting itself, and fastening on the iron-earth to the destruction of the whole texture. (2.) *Arsenic* and iron, of which the white *pyrites* consists, are too closely entangled, much more so than sulphur and iron. Whence might be sooner surmised the *weathering* or dissolution of the fossil black *arsenic*, or *fly-stone*, as being combined neither with iron nor any thing else. *Lastly*, the *arsenic* in the above-mentioned clays, also the pure, white *groove-arsenic* of *Joachimsthal*; being the *former* (from the mentioned clays being at the same time vitriolic) a *sulphur-pyrites*; the vitriol, arising from the destruction of the ore, carries along with it, by means of the water, that small *arsenical* portion mixed in therewith; the *latter* has for its ground the adjoining black-grey *poison-ore*, not our arsenic *pyrites*, as not being found near it.

(2.) In the air, the *white-pyrites* maintains itself no less constant and unchangeable in its *mixtion*, in what manner, for what time, or in what place soever it be exposed. Nay, it needs must, as it is evident, *arsenic* is the grand, if not the only cause, why the

sulphur-

ſulphur-pyrites, that are but a little *arſenical*, require more time and labour, nay even ſhow almoſt an impoſſibility of diſſolution. It is ſomewhat peculiar to the ſmalt-cobalds, that they ſtrike out a kind of peach-blooms; and alſo under certain encheirſes, yield a peculiar vitriol; nay the pure ſort do the ſame, even ſuch as manifeſt neither the leaſt ſulphur, nor *ſulphur-pyrites*; though it may be queried, whether the biſmuth-ore, which often quite unobſerved, lies interſperſed amongſt it, be, if not the principal and ſole cauſe, as ſeems probable, at leaſt a concurring cauſe: or, whether the cobald itſelf, which may here be alledged inſtead of the genuine *arſenic-pyrites*, be itſelf capable of ſuch a change.

(3.) The relation of the *white-pyrites* to the fire may be conſidered, partly in regard to the fire itſelf, partly to the other bodies. As to the firſt, moſt of the remarks, that give any light to the knowledge of this ore, have been mentioned above: but ſome things ſtill want to be cleared up; which may be beſt done by comparing it with the *ſulphur-pyrites*, and reducing what we have to ſay on this head to a few ſhort propoſitions.

(1.) The *white-pyrites* parts with its *arſenic*, of itſelf, without any *additions*, in which it agrees with the *ſulphur-pyrites*, tho' not with the ſame promptneſs, but rather reluctantly, and not without a conſiderable degree of fire. The reaſon is, becauſe *arſenic* ſticks cloſer to its earth than ſulphur does to *its* earth, which in the former is ſomewhat more crude, in both, irony; inſomuch, that in ſomewhat too briſk a fire, it is apt to cake or run, rather than to ſeparate, whereas the ſame does not happen, ſcarce even by means of art, with reſpect to the *ſulphur-pyrites*. This the *arſenic* very plainly ſhews, when combined

bined with sulphur; and in copper-ore, with a copper-iron earth: and this gives a hint to roast with the greatest caution, not with a strong, brisk fire, both the copper-ores for copper-proofs, as these never want arsenic, and the cobaldish silver-ores, for silver: also to burn well and with the greatest attention the copper-stone; as in the one a caking, or an impure silver-grain, may be expected; in the other, a great deal of *arsenical* impurity in the black-copper, with a large share of copper *speise* or *leg*. Why *arsenic* adheres more obstinately than sulphur, is, doubtless, owing to its being a metal, at least a semi-metal; whereby, in its entire nature, texture, and weight, it must approach nearer to an actual metal-earth, either iron or copper, than the tender, light, saline, and inflammable body of sulphur. Nay, all *arsenical* ores let go their fugitive, poisonous portion; for instance, cobald, whether or no it yields smalt, also *kupffer-nickel*, *red-goldish* ore and *zwitter*. Yet here we must not omit observing, as something very remarkable, that the *sulphur-pyrites*, when not at all, or but little *arsenical*, yields its sulphur very readily, and without leaving any residue; though the sulphur, which is along with the lead in the *glitter* or galena, takes a longer time for separation; sticks closer still to the regulus, as is but too well known from its incineration for making the glass, and rather carries off quicksilver along with itself than lets it go.

It may be asked, whether it be not possible so to unite a metal with arsenic, as to sublime it therewith, in the same manner as we do sulphur and quicksilver.

And here (1.) the question is not concerning a small quantity of metal, as all *arsenics* may thus affect all sorts of metals; for instance, the lead and the

the ſilver in the *lead-working*, the copper in the *black-copper-working*.

(2.) Sulphur and *arſenic* have no other affinity than that they are the two grand cauſes of mineraliſation, or of reducing metals to their ore-ſtate, and that only in regard to iron and copper: but if any thing muſt be put on a footing with *arſenic*, it muſt needs be quickſilver rather than ſulphur. *Arſenic* is a ſemi-metal, quickſilver not much other. So that the queſtion is reduced to this point, whether the *arſenic* will not alſo, like quickſilver, bear the being combined and carried over along with the ſulphur: and for this the ſandarach affords a plain anſwer, and an ocular demonſtration; as in this caſe, the carrying over of the *arſenic* by the ſulphur, happens as in the manner of quickſiver, that the third body, namely the ſandarach, educed from theſe two, may be conſidered as a *philoſophical cinnabar*.

Moreover, *Arſenic* holds firmer ſtill in its *pyrites*, when either by accident, or with deſign, it happens to cake or run together with its accompanying iron-earth; which ſhews it would ſtand the fire, and that it wants ſomething in iron for that purpoſe. The relation of iron to other metals has been ſhewn above, chap. iv. by the magnet.

(3.) 'Tis no wonder, that *arſenic*, in its ſeparated ſtate, can ſo very difficultly be again introduced into ſmelted iron; even as difficultly as it is to exhibit a *ſulphur-pyrites* by art; ſeeing it depends on a due appropriation of the iron, and the properly exhibiting its earth-form. On which encheireſes and circumſtances, many, and thoſe the moſt important combinations, eſpecially in the imitations

tations of nature, entirely depend. With *sulphur-pyrites* it in some measure succeeds; as the slag, which sometimes settles on the lead, deposited out of lead-ore by means of iron, and which certainly consists of iron and sulphur, is to be regarded as a kind of *pyrites.*

(4.) The *arsenic* in the *white-pyrites* is not sufficiently saturated with iron-earth, but can still bear with facility almost as much again, as it had already received; as may be shewn by its *regulation*, which is performed with iron. We have pure, clean sulphur, also pure clean *arsenic* in the bowels of the earth; and thus they may not only consist, but be also produced without iron.

(5.) The *white-pyrites* contains also a little silver; in this entirely agreeing with the *sulphur pyrites.* But when *arsenic* is combined with an earth, yielding smalt, and then called *cobald*, it becomes remarkably more silvery, yet in variable degrees: this we also observe of *sulphur-pyrites*, when its iron-earth is coppery. And the comparing together of the *white* and *yellow pyrites* in general, with respect to their earths; at one time yielding smalt, at another copper, and the exaltation of their silver-yield hence visibly depending, would be worth our peculiar attention. And he who would verify his suspicions about noble *miss-pickels*, should accurately examine the sample he is about to employ for proof, in order not to be deceived by other unobserved, interspersed veins therein.

(6.) The *pyrites* gold is not very common. As I would not be imposed upon by the *white*, as little would I by the *yellow* colour of the *sulphur-pyrites.* I am well aware of the difference between white and

yellow metals, a difference no way groundless; but there are middle metals, and these stand ranged with the intermediate quicksilver, and arsenic certainly should not have been excluded.

(7) The fugitive portion of the white *pyrites* is almost as well affected and inclined to iron as to bismuth, tin, and zink; whereas regulus of antimony, and lead, are ill affected and unfriendly thereto; seeing the latter can at no rate bear it nor run together with it, even when *dead*, or reduced to a glass. The former, indeed, unites with it at length, but destroys it: for the magnet, as above mentioned, touches not the iron, that is smelted with regulus; whereas it has the least aversion possible to *arsenic*, tin, zink, and bismuth, even should the iron happen to be strongly dosed with them.

(8.) White *pyrites* holds no sulphur, nor any sandarach.

(9.) It smells in the fire like garlick; its smell is biting-sharp or pungent.

(10.) It diffuses its smell in the air to a greater distance than sulphur does.

(11.) In the strongest degree of fire it leaves a black glass behind, as we experience of any other iron mineral.

(12.) *Arsenic* makes copper white, but at the same time brittle.

(13.) It leaves iron its colour, and makes it eager also.

(14.) The

(14.) The glass, to which it runs along with lead, is something extraordinary: not to mention other remarks at present.

Once more; *arsenic*, *zink*, and phosphorus, stand greatly allied to, and probably are derived from each other. Zink and phosphorus are bodies susceptible both of fire and flame; the former, only by an external accension; the latter, by an internal self-motion, by means of the air. Zink smells fetid, like phosphorus, and phosphorus smells like hut-fume. Phosphorus unites with quicksilver. *Arsenic* and quicksilver are nearly allied. In *cadmia fornacum* there is an actual, tho' not a formal zink. *Arsenic* certainly lodges in, and zink is only derived from ore: yet they are produced one after the other; first, the *arsenic*, then the zink; they also adhere to each other. Phosphorus too may be prepared from *arsenic*, or an *arsenical* body.

Reader, weigh well what I have already mentioned on this head; and here, for thy further information, take an extraordinary experiment of the celebrated Dr. *Meuder*'s *Dresden*, lately discovered by him, and imparted to me: Take orpiment and iron-filings, equal parts, and subliming the mixt mass in a body or cucurbit, among the sublimate, thus procured, rub in on a porphyry, ten or twelve parts of lunar crystals; then shooting out the whole on paper, it will instantly take fire.

CHAP. XI.

Of the Silver in the Pyrites.

AS to the *silver* in the *pyrites*, it is an undoubted truth, allowed by every careful assayer, and which I myself have experienced, that *pyrites*, as such, never holds above half a drachm of silver in the centner. For, tho' sometimes the proofs should rise to 1, 2, 3, 4, 5, and 6 drachms, as I have often observed such various *yields*, we are at the same time to know (1.) That such sort of *pyrites* is commonly coppery; and that the copper therein is, if not the cause, yet the sign of the admixture of other ore. (2.) That such yieldy *pyrites-mixt-work*, or *pyrites-meal*, has often other veins unobservedly interspersed amongst it, which may greatly raise and heighten the *yield*; and to this sort may be sometimes referred the cubical, marcasitical *pyrites*, such as those of Pretzschendorff, which appear pure and unmixt, tho' internally they make an appearance of being *glittery* and *mock-leady*. (3.) That hence the proofs vary much, nay sometimes so far as to fall short of half a drachm.

The same thing holds of the *white pyrites*, namely, the *misspickel*, or *poison-pyrites*, an half, or a quarter of an ounce may often be procured from them; but a drachm, half a drachm, and next to nothing at all, are generally what the *proof-schedule* shows. Yet here, for particular reasons, I must allow some silver to the *white* rather than to the *yellowish*, or sulphur *pyrites:* and I have been informed from Sweden, that they have there a *misspickel*

of

of four ounces in *ſilver-yield*; though it may be queried, whether ſuch be a pure *miſspickel*, and not rather a ſmalt-cobald, theſe being often not eaſily diſtinguiſhable, and generally *ſilvery*. But here again I find, even a *miſspickel*, that *breaks* in amongſt the nobleſt veins, tho' rarely, to be no more *ſilvery* than another from coarſe veins.

But when the *pyrites* is coppery, as from the copper-yield we may ſuſpect the coction of ſome other ore and metal, we may then rather hope for *ſilver*, tho' not conſtantly, not indeed as an eſſential, but as an incidental part of the *pyrites*, in the ſame manner as copper itſelf is ſo. Nay, this incidentality of the *ſilver* in *copper-pyrites* is ſtill ſo uncertain, that there is no meaſuring or proportioning the yield of the *ſilver*, as might be imagined, by that of the copper. But there are *copper-pyrites*, very rich in copper, which nevertheleſs do not yield the more *ſilver*, nay ſometimes yield leſs than thoſe that are poorer in copper. And here we muſt be upon our guard againſt being impoſed upon by names given to *pyrites*, either from the colour, the *ſilver-vein*, where they *break*, or their uſe in ſmelting for *ſilver*.

Thus, from Norway, I have had, under the title of a *ſilver-pyrites*, a barren ſtone or rock, conſiſting of ſmall, tender layers of *quartz* and *glimmer* interchangeably, with foils or ſpangles of *ſilver* upon it, where it had been broke off. Now, not to mention, that we are not careful enough to diſtinguiſh *pyrites* from flint or *quartz*, which this ſtone really was, I ſhall here only obſerve, how far-fetched ſuch denominations often are, which point not at the eſſence, but accidents of things; as ſuch pretended *ſilver-pyrites* hold no *ſilver* of themſelves,

P 3 but

but happen to be furnished with only such as is adventitious and foreign. The same judgment we ought to pass on the Latin appellations, *pyrites argenteus*, or *argentarius*, as taken either from the colour, and denoting the same as *pyrites argentei coloris*, and thus only a *white pyrites*, of which in the preceding chapter; or, from its holding silver only without any other metal, as * *Rulandus* affirms; whence it should rather have some other name than that of *pyrites*. After all, so little *silver* is to be expected from *pyrites*, that were not the *sulphur-pyrites* serviceable for making the *crude-stone*, or for sulphur and vitriol; and the *copper-pyrites* serviceable for copper, it would not be worth while to dig for and smelt them.

* Lex. page 390.

CHAP.

CHAP. XII.

Of the GOLD in the PYRITES.

IF silver hath no great share in the *pyrites*, gold has still much less: I, for my part, find little or none therein, though nothing be more common in the mouths of men than the names, *gold-pyrites*, *gold-marcasite*. It is, I own, no small pain to me, to be obliged to contradict what so many ingenious and learned persons before me have asserted to this purpose; however, I cannot help exposing such pretences, seeing even what actual *gold*, after the greatest care and attention, we may happen to procure from *pyrites*, proves very inconsiderable, and next to nothing; and then it may be queried, whether it was actually in it, or produced by means of the process and *additions*. 'Tis absurd to pretend, in support of the common opinion, the volatility of this *gold*, as it may be asked, what the appearance, and what the signs are, by which it may be distinguished? We have, 'tis true, volatile metals, in particular, the common and philosophical leads; nay, all metals may be volatilised.

But it will be alledged, there is no catching this volatile *gold*, *in an open fire*; but may not subliming vessels be employed, by means of which, a little of what the violence of the fire forces off may be recovered in order to trial? But, to save my reader a good deal

deal of trouble, I can aſſure him, that after having examined all the ſorts of hut-fumes, from the ſeveral operations of *crude-working*, working for lead and copper, and thoſe from the fining-hearths, with a view to this volatile *gold*; I found, indeed, a ſmall ſhare of ignoble metals, in particular, lead and copper; alſo a little ſilver in the lead, but never the leaſt ſign either of a volatile or fixed *gold*; as thoſe employed at the roaſting-hearths and ſmelting-furnaces, for collecting the diſſipated ſilver, and who having aſſayed the ſilver procured from the fume, for *gold*, will readily own. Tho' had this ſurmiſe any foundation, the *gold* could not fail ſhewing itſelf in ſuch hut-fumes, where *pyrites* of all kinds, and in all quantities, are worked, in a degree of fire, where all metals muſt become fugitive. That in Hungary and Tranſilvania ſome *gold* ſhould be procured from the fume-works, we are not to wonder, as their ores contain a fixed *gold*, which, like the ſilver with us, may be carried off in the arſenical fume in very minute particles; but, by the method of depart, or by the aſſay-furnace, no violence of fire can be charged with volatiliſing the *gold*; and yet in neither of theſe ways do we diſcover any in the *pyrites*.

Should it be further alledged, that it is only an immature, or embrionated *gold*, this is no more than a mere ſubterfuge; 'tis as eaſily ſaid, that cobald, tin, and the like, are an immature ſilver, as is, indeed, often ſaid, but never proved; tho' it muſt be allowed, tin, and the like, greatly reſemble ſilver. *Pyrites* alſo boaſts of its beautiful gold-yellow, which has ſerved to deceive many, without their being able to procure any one ſort of *gold* from it.

I would

I would not here be underftood as depreciating the following propofitions, *viz.* (1.) That a perfect, or, if you rather choofe it, a ripe metal, may be made from an imperfect metal. (2.) That fome *pyritæ* are not entirely without fome fmall fhare of *gold.* The firft the experience of every one may affirm, in the leaft converfant in the bufinefs of minerals and metals, with any care and attention; though the thing cannot be reduced to any certain theory or rule, to be depended on at all times. But in all thefe proofs, where, for inftance, copper and iron particles are tranfmuted or converted to *gold*, as alfo fome particles of lead, tin, regulus, *&c.* to filver, it by no means follows, that iron and copper are an immature *gold*; or lead, tin, and regulus, an immature filver.

For, though I might call fuch a converfion a maturation, and though there were inftances thereof, yet it ftill remains a queftion, whether other, nay, all eductions of the nobler metals, where a formal tincture is not employed (and fuch proceffes may, in fome meafure, be called *particular)* are only *productions*, arifing, as a third thing, from the running and mixing together of two or three forts of particles, and not, in effect and propriety, *eductions*, not always to be denominated maturations, or tranfmutations.

It is one thing to tranfmute a falt, for inftance, to volatilife common falt *per fe*, which is certainly practicable; another, to educe a falt by the addition of a fecond and third matter, as an *oleum vitrioli dulce*, by means of quicklime, or a lixivious falt, as is a well known cafe.

Metals,

Metals, undoubtedly, are near allied to each other; though why supposed so only in the ascending, and not the collateral line? and philosophers borrowing the term *maturation* from the vegetable kingdom, it is only in the way of comparison, and serves merely as a demonstration, but does not amount to an illustration: either it is out of a certain deference to the *great work*, they forbear the use of the term *transmutation*; or, to avoid falling by the ears with the Aristotelians, who, from their doctrine of *genus* and *species*, disclaim all transmutation of metals.

Before I enter upon assigning the quantity of *gold* procurable from the *pyrites*, I must premise my method of taking and working the proofs. For the first, with the greatest care and attention possible, I pick out the pure steely or close sort; then, as the *gold* in the *pyrites*, if any, is only to be had by procuring its silver, in the *grain* of which the *gold* lodges, I have accordingly made the proofs for silver; and as, generally, the *silver-grain* proves to be very small (and neither the smallest nor the largest is to be assumed) namely, in the *sulphur-iron-pyrites* amounting to half a drachm, and in *copper-pyrites*, or copper-ore, to two drachms; with so very small a *grain* there is no making a certain proof for *gold* by the *depart*; I have therefore worked between six and eight centners at once, on as many different assay-pots and copels, and, at last, run the silver together into one *grain*, which afterwards committing to the *depart-water*, I, after edulcoration and ignition, weigh the black calx. I hold this to be the best method, as it supersedes, if nothing happen to be procured by it, the several operations of cementation, maceration, ignition, and extinction, if you will suppose there is any *gold*; for, some

some of these, particularly cementation, may have some effect as to the encrease of the gold.

To educe the *gold* out of the *pyrites* by *aqua regis*, seems to be an uncertain method, as the *gold* is generally entangled, not only in much foreign admixture, but in such metals, as copper and iron, on which *aqua regis* equally works as on *gold*; yet this I have also done, and, after *incoction*, copelled the precipitated mass, but without any effect; nay, if by the former method I procured any thing, by the latter, on the contrary, I have rarely succeeded at all, or in a far less quantity.

In pure *sulphur-iron-pyrites* there is not the least *gold*, a thing well to be observed, even should it happen to be the *minera martis solaris Hassiaca* itself, the sulphur of which, for its high purity, is greatly to be valued (but its vitriol must yield to a factitious, pure iron-vitriol, but much more to a vitriol from calamy, also to the green, fossile, Hungarian vitriol) but its *gold* is only imaginary: much the same holds of those *iron-pyrites* which are but very little coppery, as also of most *pyrites* in nature. Among these there is now and then a proof, where the *mark* of silver holds about one quarter, or one half, or one *heller* * of *gold*; but when the centner or quintal of ore gives forth one, one half, nay, only one quarter of a drachm of silver, and you come to calculate the number of centners of such ore, necessary for the eduction of a mark of silver, the *gold* to a centner must be very inconsiderable, nay, not to be calculated, much less be visible, or be manifested by the most tender, sensible scales; can it then be thought worth while to mention *gold* in this case?

But

* Seven hellers make a penny weight, thirty-two hellers a loth, or half ounce.

But it will be alledged, the *copper-pyrites*, and *rites-copper-ores*, as copper is nearer allied to *gold* than iron, yield ſome *gold*; yet with theſe, after all my labour and trouble, I ſucceeded no better. It may indeed happen, that ſome Hungarian ſorts, which have ſerved to ſet the world a-gog after *copper-pyrites*, ſhall give ſome evidence of their containing *gold*; but of theſe hereafter. One would not readily ſuppoſe *gold* to be in the white or arſenic *pyrites*, ſeeing it does not appear yellow, but of a ſilver white, which is the reaſon the beautiful yellow *pyrites* have been pitched upon, though that yellow caſt be only owing to their ſulphur, and afterwards heightened by the copper, nay, often ſuperficial only; and as little from the colour muſt we imagine ſilver in the white *pyrites*; though it contains ſuch powers, that, under a due doſing with other matters, may contribute ſomething towards the eduction of both ſilver and *gold*.

From the ſeveral proofs I have made of a variety of *pyrites* from different parts of Germany and Hungary, I have found, that the ſort yielding *gold* have had either tender and unobſerved eyes of richer ores, eſpecially rich ſilver-ore, or ſpangles of native gold, or ſome *quartz* (in which gold generally lodges, and not in *pyrites*) entangled and mixed with the ſample under examination; and therefore, before ever the ſample be beat quite fine, and committed to the furnace, it is highly neceſſary carefully to inſpect it both by the naked and armed eye, and to omit making no experiment that may contribute to diſcover it, as *gold* may lie concealed in the tendereſt ſpangles and duſt: as (1.) ignition, whereby the *gold* is not only heightened in colour, eſpecially when it happens to be ſmutted,

or,

or, by means of a mercurial admixture, over-pale, but to break and crumble the ſample which is commonly *quartzy*, and thereby to expoſe to view more ſides of veins, where the *gold* commonly lodges; and the *pyrites*, for which the *gold*, being ſo crude, cannot always be diſtinguiſhed, becoming dark, the *gold* muſt needs ſhew to the greater advantage: (2.) amalgamation, on which the moſt ſkilful hands ſhould be employed, as the *gold*, being in ſuch tender ſpangles, is apt to float on the water: (3.) *aqua regis*, which is ſtill better, taking the ore crude and unroaſted: laſtly, the repeating the proof; when the difference of yield muſt at leaſt ſhew the *gold* either accompanying, or lodged in the *pyrites*.

The following remarks may here be juſtly made; (1.) that as no great ſtreſs is to be laid on the cubical or marcaſitical, as little is there on the round figure of the *pyrites*, for their *gold-yield*: (2.) that the pale-white colour of *pyrites* ſhould be no prejudice againſt our examining them for *gold*; nor its yellow colour, either that eſſential to its *mixtion* (ſuch as the *copper-pyrites*) or ſuperficial only, from an external *weathering*, be any prejudice againſt their *gold*: (3.) among all the ſorts of *pyrites*, I have never met with any containing *gold* alone (namely, in an *ory*, pyrity ſtate) without ſilver, a circumſtance worth our greateſt attention; and it may be doubted, whether there is an inſtance of a ſingle *gold-ore* in nature: (4.) that there is no *pyrites* whoſe ſilver does not conſiderably exceed its *gold-yield*: laſtly, that the *gold-yield*, of any conſequence in *pyrites*, generally amounts to a penny weight in the centner, or a little over or under; which conſtant proportion makes it highly probable, the *gold-yield* is procured from the *pyrites* as ſuch, and not

not from native *gold*, or other accompanying veins, seeing the proportion would, in that case, prove various and inconstant; and then the question will be, whether the *gold* be produced from it?

Now when there is *gold* in *pyrites*, and I would procure it, the body of the *pyrites* must necessarily be destroyed, ceasing to be what it was, and in part commencing a different thing, a new production, mixtion, and composition; as we have a convincing instance to this purpose in vitriol, a matter not lodged in, but produced from *pyrites*.

In the first place, I speak of such destructions as happen *per se*, without the addition of other matters; for instance, common and corrosive waters, salts, oil, sulphur, &c. poured, rubbed, or mixed in variously, though not without all material influx of the air and fire: (2.) of such destructions as are commonly called *processes*, wherein, along with *pyrites*, are mixed-in saline, sulphureous, mercurial, and arsenical matters, also metals and semi-metals, which have usually some effect: (3.) I would ask, whether there may not be methods, where, from the running together fit particles, there may not, by means of action and re-action, impregnation, and conception, new substances, forms, and productions be procured; and thus something of *gold* be procured, that neither was in the subject, nor in the additions. Now, (1.) as to the destructions happening without any palpable additions, and the concurrence of any other matter, which might be held as barely instrumental, without the suspicion of any *material* influx on the mixtions, as the lead on the copel, not certainly to be regarded with the common eye of an assayer; the depart water, which, in its habitude

bitude and fitness to its subject body, shews something more than a bare instrumentality; or, at least the *aqua regis*, and the precipitant employed for discharging out of it again the earth swallowed up by it: I say, not reckoning these, the destructions of mineral bodies in general, and of ores in particular, not only cause separations, but transformations also; not only exhibiting to view what they contain, but also some new *mixt*, a third body; and that for this reason, namely, that they are generally *decompounds* and *superdecompounds*: and not only *compounds*, but mixts, nay, simple particles themselves, which, when brought, either by the fire or air, into a state of motion, activity, and conception, operate upon each other.

By means of destruction, the parts of the whole separate in one part, and again unite in another, or let go some of their *mixtion*, that others may combine the closer; and these new combinations happen in the very act and instant of the separations themselves; as in the case of vitriol, which is not actually contained in, but generated from *pyrites*; as is evident, that in the production of it, the entire body of the sulphur is excluded from communicating but a part, namely, its acid salt; so that its own proper subsistence, as a sulphur, must needs be destroyed. The parts forming the new production are often already in the subject, and only a new cohesion or texture procured; frequently they are fetched from some other quarter, either apart, or together, and often arise from the destruction and mutual action of the parts, once set loose and rubbing against each other. The vitriol-acid, and the metallic-earth, are both contained in the *pyrites*, and that in a large proportion, only not in a vitriolic mixtion; but the former

mer in the sulphur, the latter not only entangled in the sulphur, but also in another crude-earth. In *alum-shiver* there is no vitriol-acid at all, but it is fetched either from the air, or generated at once by fire and air, or by fire alone; tho' fire, without air, can neither act *instrumentally* nor *materially*; neither is the white earth of alum procurable from the ore, nor therefore to be considered as a genuine production.

The water, which is in a large quantity, both in vitriol and alum, is neither in the *pyrites* nor alum-ore, considered in their *mixtion*, but is imparted to it either from the air, or by men's hands. The same also holds of other vitriols, produced from their own ore alone; though I cannot here recollect any but the white, and the sort from bismuth-ore and cobald, or from bismuth itself, as I have experienced. The former contains a white, though coppery earth, which is neither from the ore, nor from the accompanying shivery, loamy, and *knissy* minerals; the latter, or the bismuth-cobaldish, a green, though derivable from the ground-earth of the smalt-cobald-ore, as green and blue are in nature near allied; but the peach-bloom colour, nay, the purple-red, as their beautiful appearance deserves a peculiar regard, must needs have their foundation in a peculiar conformation of their earths.

Thus in these productions, formed as much as may be *per se*, foreign matters, as air and fire, have an influx; often the air alone, as in the spontaneous vitriolisation of *pyrites*; often the fire alone, as in the vitriolisation of calamy; often both together, as again in the vitriolisation of the *pyrites*, which must first pass through the fire, and afterwards be exposed

exposed to the air, but properly both together, unless you would have a coaly or externally inflammable sort. Air and fire are here to be considered not only in their *instrumental*, but also in their *material* capacity; or if they must be called *instruments*, *immanent* rather than *transient*.

The air chiefly manifests its virtue on, and ingress into the bodies of plants and animals, as in good part not only being derived from it, and remaining under its influence, but as being of a softer texture; nor can minerals, least of all the sulphureous and bituminous, resist its action: nay, these are chiefly the bodies on which it performs destructions, separations, and new combinations, as sufficiently appears from vitriol and alum. In the *depths* of the earth it operates on minerals more powerfully than at the *day*, as being not only more actuated with a greater number of saline particles, but not so subject to be dissipated by the action of the wind and sun, consequently it has time and leisure to eat into veins and rock; nay, to destroy such bodies as, exposed to the open air, remain untouched, or become still harder, and more durable. It not only penetrates, but at the same time adheres to what it penetrates, with its fatty, saline, earthy and watry particles, which last are the vehicle wherein the others lodge, and are introduced and incorporated into the subject. The fatty and saline nature of the air cannot be disallowed by any one, considering its meteors, in particular, thunder and lightning, the habitude of pot-ash thereto, the corrosibility of iron and copper therein, &c. Only 'tis here to be hinted, that we do not extend too far the action of the acid of the air to the vitriolisation of *pyrites*, as being what is already plentifully present in the sulphur of the *pyrites*;

rites; a desulphurated *pyrites*, and an exhausted *caput mortuum*, never yielding any vitriol.

Fire, which consists in the quickest degree of motion and incalescence of inflammable, fatty particles, imparts to the mixtion, partly from its own matter, partly from the flame of coals, wood, *&c.* applied externally, or from both together, something essential and material, that either before was not at all, or not in such mixtion and form therein; as appears from an incinerated regulus of antimony, which proves heavier than it was before such incineration; and from all the transformations of bodies containing any thing inflammable, which by the external fire is ever made the object of its own rage.

In all these dissolutions, new forms, or new productions, frequently occur, where separations are seldom seen; yet where destructions happen *per se*, and are purely the effects of air and fire, without any thing besides, there we may rather expect separations, and that in mineral bodies: and if we would proceed accurately, the separations are to be verified by compositions. I speak of mineral bodies, and those both *compounds* and *decompounds*; for, animal and vegetable bodies easily and certainly enough separate into their original earth and water, out of which they grew: and *mixts*, nay, often *compounds*, are of a nature, that the former bear not separation at all, the latter, not without some difficulty. In separations the parts of the body are already *formally* in it, what is otherwise produced, *potentially* only. Of the fire it is commonly said, that it is unfit for separations, as framing new mixtions only; that the fire is a *destroyer*, not an *analyser*; that the air, on the contrary, is a better separator

parator and dissolver; but in *decompounds*, such as minerals mostly are, the reverse may rather be affirmed; for, the fire rightly enough dissolves the *pyrites* into its parts, so as separately to exhibit its sulphur, arsenic, copper, and iron; whereas the air, by the act of vitriolisation, quite destroys the sulphur, not to mention the metallic portion, which in this case is taken into the vitriol-mass, and thus becomes transformed.

Now to apply this to our *pyrites*; it may justly be asked, whether the *gold* be parted, or formed from it, and thus be either *formally*, or *potentially* therein? By spontaneous vitriolisation a *gold-yield* is neither to be induced, nor increased in the *pyrites*; nay, though by these destructions there happen extraordinary precipitations of some earthy particles, that often partake somewhat both of *gold* and silver; yet such conjectures are with difficulty proved: for, *gold-pyritæ* are either coppery, or arsenical, or participating generally of both. Now suchdo either not sufficiently, or not at all vitrio-l ise;and fossile or native ochres, or *pyrites-earths*, several times assayed for *gold*, I found to have little or no yield.

Suppose now we have recourse to the fire, and then the *pyrites* either is, or is not roasted; in the latter case, it is taken crude, dosed with lead, and scorified, and the lead-regulus *driven*, or copelled, that is, the noble is driven or parted from the ignoble metal. Now here we procure a *silver-grain*, at least from the lead, were there no silver at all in the *pyrites* itself; in this *grain* the *gold* must lodge: this *silver-grain* is committed to depart-waters, namely, the *gold* parted from the silver, and ignited, which finishes the process. Now though

 this

this method of working *pyrites* for *gold* ſhould ſeem to be performed *per ſe*, without any foreign additions, yet that there only happens a bare ſeparation, as no methods of coction, maceration, digeſtion, and maturation, have preceded, may prove a mere precarious aſſertion, without conſidering in the leaſt the nature of lead in its volatility and activity, the efficacy of ſulphur, and the mercurial ſeminal virtue of arſenic; eſpecially when theſe powerful agents happen to be applied to, and to find proper tender matrices. All theſe are here effectually applied, whether the operation be carried on in the way of roaſting, or of ſcorification with lead, the metallic earths exhibiting themſelves as ſo many tenderly prepared matrices: and ſuppoſing the parts of the *pyrites* to do nothing towards the transformation and exaltation, yet the fire acts here no inconſiderable part, not only in the way of a ſeparation, but alſo of an influx; whether by enriching the *phlogiſton*, and metalliſing the matter, or by a higher virtue ſtill, may be made a queſtion.

Whilſt I was engaged in theſe reflections, there came to my hands an extraordinary experiment of M. Homberg, from which he maintains, and with a good deal of probability, that in ſilver are contained particles of a gold-nature, which, in the courſe of the proceſs, at firſt become perfect *gold*. ‘ Take between one and two *marks* of ſilver, which ‘ being aſſayed in the uſual manner, with *aqua-* ‘ *fortis*, in order to aſcertain its containing no *gold*, ‘ melt it an hundred times over, and having con- ‘ tinued it each time in flux for an hour at leaſt, ‘ *depart* it; you will procure a very ſenſible quan- ‘ tity of *gold*, which before was not to be found ‘ in the ſilver *.’ ’Tis pity our author did not ſet down

* Mem. de l'Acad. &c. l'an. 1709. p. 141.

down the weight of the *gold* procured; also, that he does not inform us, whether the process was carried on with the same parcel of silver, and with the same *yield* over and over; though this cannot be, at least, seems not credible, as may appear from his second experiment, which shall be mentioned below, and as may be concluded from his judgement on it; and lastly, we have not Homberg's purse, for repeating such experiments. We may, however, firmly rely on his veracity, and conclude from this, how much reason we have, even in such mineral and metallic processes as happen *per se*, to expect new forms and productions.

For, in the experiment before us we have no ore, but a simple, and every way well parted metal; no *compound*, but a *mixt*. Here we have neither sulphur nor arsenic, as is in *pyrites*, nor lead, nor any thing else added: yet, how simple soever silver may appear, it is not really so; it ought to be observed, as appears from Homberg's second experiment, that the whole of the silver is not converted to *gold*, but only some particles, which have their certain number, weight, and measure, and are produced all, if not at the first, yet at the second and third trials. And what is it in silver, which thus is no silver? probably an earth.

A foreign metallic earth may be contained, to a considerable quantity, in silver, as may be judged from the universal mercurial affinity of metals, and particularly of iron-earth, which, notwithstanding, cannot escape *depart-waters*, and often proves to be that fallacious black calx, which we take for a *gold-calx*, though in fact it is no such thing: and if this earth, which turns to *gold*, be an iron-earth, may not the like, with more probability, be supposed in

pyrites-silver, as *pyrites* always contain iron; and *gold* be in quicksilver *potentially*, not *formally* and actually, but only in the proximate degree of becoming such. Hence appears, how much depends upon time and fire, and how, from the defect of one or the other, particularly of the highest degree of a glass-house heat, we may after chance to miscarry in all our designs; and that what we may be apt to ascribe to extraordinary *additions* and secrets, may only be the effect of patience, time, and fire.

In the next place, Becher's experiment of making iron from loam and linseed oil offers itself to our notice; and this leads me to consider such ore and metal-smeltings, where the coal and flame happen to be in immediate contact with them, as is the case at all huts for smelting-ores; this also gives me an opportunity of clearing up a little more the question about the transformation of metals, and their mixtions; how they happen *per se*, or, at most, barely by the fatty wood-coals, and other, either vegetable or animal particles, coming to play in among them. For, though M. Lemery's reflections on this experiment staggered me greatly, in regard to Stahl's opinion about restoring the phlogiston, and its *material* influx on the metallic earths, nay, almost brought me over to be of his mind, yet I shall vouch for neither opinion, but leave them to stand or fall, at the judgement of the reader. M. Geoffroy, a member of the academy of sciences at Paris, did, in the year 1705, on occasion of Becher's experiment, start the following question, viz. *Whether it were possible to find plant-ashes having no iron?* or more distinctly, *Whether those iron-particles, actually procurable by the magnet from vegetable ashes, were really in the plants* *in*

in their fresh and unburnt state, or first produced therein by the act of incineration and burning? M. Lemery the younger, reasoning from the possibility of the thing, affirms the *first*; as from iron being contained in all upper garden-molds, whence plants must derive their nutritious juices: again, from iron, by means of water, changing to a salt or vitriol; to which might be added, that vegetable waters may affect what a formal acid vitriol salt cannot; as sufficiently appears from that macerating water, prepared for the use of iron-plates, from the fermented acetous juice of corn, of which we shall say something in the chapter on vitriol. After this, M. Lemery sets about examining the matter of fact, yet without alledging any one solid proof; only denying the allegations and conclusions of his antagonist, and, at last, answering his objections. M. Geoffroy undertakes to defend the *last*; and here he chiefly asks, how' tis possible for such a vitriolic vegetable juice not to affect the taste, as a single grain of vitriol may serve to impregnate several measures of water. Though the dispute seems to be but lamely managed on both sides, yet it must be allowed that the former has the advantage, at least in point of answering objections, tho' not that dexterity at defending his own position; and that, though I have always suspected the original of this iron in plants to be rather in their incineration, yet I cannot hitherto find proofs sufficient to satisfy myself, much less another, about it. And here the question is not, whether the iron-particles do, or do not actually lodge in the substance of the plant, the linseed oil, &c. but rather, whether the linseed oil, and the clay, or loam, do, by the operation, yield any iron, which before was neither in the one nor the other: for, M. Geoffroy readily allows, that both in the loam and oil, there is al-

ready some of this metal, previous to their addition, namely, *per se*, as appears by the magnet; tho' I doubt much, whether there be any in loam as such, a pure marl-earth. And M. Lemery cannot deny, but that by the addition more iron is procured than otherwise would from the matters taken apart: yet neither thus is the dispute at an end: for Geoffroy alleges that the marl, in order to its becoming iron, wants something, which by means of the linseed oil must be communicated to, and incorporared with it. Lemery, on the contrary, insists, that it wants nothing, only some impediment remains to be removed: the former, that there is no iron yet, but that it must be first produced: the latter, that it is already formally therein, and wants only to be separated from the foreign matters, that hinders its assuming a metallic form. The former, that what in the clay or loam stands in the way of the metallisation, as also of the magnet, is an acid, which may be removed by a fatty matter, as an absorbent or alcali; which appears not improbable, from the following circumstances; first, that acids usually reduce metals to an earthy, loamy form: again, that metals do by calcination rather encrease than decrease in weight, and thus lose nothing, that must again be refunded, but rather gain something.

But not to insist on the acid in loam and clay; a small matter therein cannot greatly contribute to fill up the pores of so much iron, as may be procured from it, there being more than a little acid requisite to reduce to earth only a small quantity of iron: or otherwise, I find not such a similitude of circumstances, as to believe, that an artificial metal-earth agrees only in this with a fossil. But it may be answered, which yet, I think, is not to be allowed him,

him, that when the formality of this experiment consisted only in removing an acid salt, and the vegetable fattiness acted here as an alcali; this fattiness, as such, and in its unaltered state, cannot be said to effect it; but may, when in the course of the operation it becomes reduced to an actual ash, and thus to an alcaline state. For, oil and fat, as such, remove no acid; but consisting themselves mostly of such, encrease its quantity rather; but a lixivious salt effects it.

Still several difficulties offer that oppose a positive declaration from *Lemery*'s opinion.

(1.) There will be requisite a much greater quantity of alcali to obtund a certain quantity of acid; and in loam, by his own concession, there is much acid. Again, what quantity of alcali ashes does linseed oil afford; nay, how much pure alcali is procured from the ashes?

(2.) Why are not metallic earths reducible with pot-ash and the like; and *lunæ cornua*, not again to silver, but much, nay almost all of it lost, when repeated by trials with alcali: whereas pitch, fat, rosin, and the like do, under proper treatment, reduce all the silver *back* to its metallic form: and yet, in the one case, such fatty matters scarce in their whole substance and weight amount to so much, as does the pot-ash employed in the other, tho' without any effect: and the least quantity of coal-dust reduces my *antimonium diaphoreticum*, as also my *vitrum antimonii*: whereas the former floats in the alcali, and under due cover and screen from coal-dust, for ever remains an earth, or goes sooner off in fume.

What-

Whatever probability there may be for Lemery's opinion in the encreafe of weight of fome metallic calces or earths, a thing not to be denied, yet till other convincing experiments can be produced, I hold the actual caufality, or the formality of Becher's experiment to confift, not in removing matters, ftanding in the way of the metallifation; nor in a way of unfolding all the iron-particles already extant, but in a material influx, and an addition of parts deficient; in an effential communication of the metallifing fattinefs, and thus in a real formation. Confequently, that there is nothing in Lemery's opinion that can in the leaft invalidate my notion; not only in regard to the metallifation of a *gold-earth* in *pyrites*, but alfo principally, in regard to the production of *gold*, extant therein neither in a metallic nor earthy form; alfo in regard to the bufinefs of transformations, nay even tranfmutations.

To illuftrate the deftructions or diffolutions, performable by *additions*, and not by air and fire alone, I fhall here alledge M. Homberg's experiment, promifed above. 'Take and diffolve a 'mark of filver in aqua fortis, and remove what 'remains undiffolved at the bottom of the glafs: 'throw down this folution with common falt; 'adulterate well the precipitate, and dry it. To this 'filver-calx take half as much regulus of anti'mony, well purified and reduced to a fine pow'der: mix all well together, and being put into a 'retort, drive it in a fand-heat, and there will 'come over about three ounces, or fomewhat 'more, of a butter of antimony: raife your fire to 'the higheft pitch, and you have the filver at the 'bottom of the retort, mixt with a part of the 'regulus of antimony. Put this filver into a cru'cible in an open fmelting fire, wherein let it fume, 'till it can no longer, or till the regulus be entire-

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'ly gone off. Melt this silver once more, nay 'twice, with a little borax and salt-petre, and it 'will prove as fine and ductile as a tested silver. 'Then granulate and dissolve it in aqua fortis, and 'you will have a number of small black flocks, 'which being melted, prove to genuine *gold*. Re'peat this with the same silver a second and a third 'time, and you will always procure some black '*gold* calx. In the first process, the particles, 'which are proximately fitted to become *gold*, be'gin to be perfect, and fall down as small black 'flocks. In the second, there are some more pre'pared and perfected; and in the third, none at 'all: when it appears, that the particles, fitted to 'become *gold*, are by the two first operations 'quite exhausted, or drained out of the silver.

'Here it may be objected, that the regulus of 'antimony (*regule de Mars*) has produced or 'educed this black calx from itself: if so, there 'must as much be procured in the second and 'third operations as in the first: whereas in the se'cond, there is not so much as in the first, and in 'the third, none at all. To this add, that we 'very often meet with grown, native *gold* in the 'earth, much paler than a fine sort should be, yet 'without yielding the least silver, and which, by 'a repeated smelting, begins to become perfect, 'and to attain its due colour. Thus we find in 'silver a matter that turns to *gold*; and in *gold*, a 'a pale (blanchatre) matter, which by the fire gains 'the genuine *gold* colour. These are the two mat'ters, which are a middle metal between *gold* and 'silver, but which remain not long in this state, 'being by each smelting brought still more and 'more to the perfection of gold *.'

* Mem. &c. l'an. 1709. p. 142, seq.

This experiment afforded me a double pleasure; *one*, as it is so much adapted to our present enquiry, and may yield no small matter of reflection to those, who, while they attend the business of separations, overlook that of introduction: *another*, and not the least circumstance, is omitted, but which is very needful for the information of the curious imitator; especially as it attributes to the silver, what one might be apt to ascribe to the regulus. As in silver, not indeed in all, something may lodge, which by certain *additions*, may be educed from it, so the same may with probability be affirmed of ores: and here the *additions* may be made in three different ways; either with other ores, with metals, with unmetallic earths, or with sulphur or arsenic, or both together, under a proper previous preparation: not to mention at present salts and sharp acid waters, which are foreign to our present design.

(1.) Ores may not be so well adapted, unless previously one of them be made receptible, and thus fitted and prepared; or be, in regard to the two middle-minerals, sulphur and arsenic (the two grand mineralising matters) of a different nature and habitude: for, not only do those volatile bodies operate on each other, but the arsenic may, by means of its standing the fire longer, wait the desulphuration of any other ore, and into this introduce its own naked hungry earth; unless by an undue degree of fire its efficacy happens to be destroyed; or a fit metal lodging in the one, with which appropriated earths may be brought into mutual action, they are both lost.

(2.) I find metals better fitted for *additions* for *pyrites*, and these not so much in their metallic as earthy form, so they be otherwise adapted to the subject.

And, (3.) Earths seem of more importance than we commonly imagine, from the prejudice of considering them only as dead, inefficacious bodies: for, tho' we may not always allow them activity, yet a passive receptibility we often may.

I know of earths, not only devoid of all *gold* or silver, but of any other metal, yet combined with *pyrites*, yields silver in a proportion never to be found in *pyrites* alone. There are earths, looked upon as dead and effete, which in obvious circumstances, particularly phosphorus, manifest the greatest degree of activity. What are salts other than productions from earth, only that they appear not in their saline form in all operations: and salts and earths are ever mutually convertible; salts turning again to earth, as is a known case. And M. Rosinus of Munden sent me a white crystalline salt, greatly resembling a Glauber's or an Epsom salt, and prepared from a sort of stone, without the addition of any saline matter: which seems to be confirmed, from observing, that mineral bodies, manifesting nothing saline, as bismuth ore and cobald, much more *alum-shiver*, do barely by means of the air yield an actual salt.

These things being premised, we are to consider the *gold* in the *pyrites* in a threefold view:

(1.) As it is seen in the common way of proof, by means of lead and aqua-fortis.

(2.) As

(2.) As procurable by the aid of additions:

And, (3.) As an *over-shot*, or overplus, not discoverable in the common method of proof.

As to the first, I shall wave the questions relative to the presence and eduction, and only leave to reflection, why copels, that have been in use, and thus are become glazed with lead, yield upon re-fusion, more silver than the *lead-grain* of such lead originally amounted to; and whether ever any one assayed his lead for *gold?* The effects of lead and cupellation, are, certainly, considerable; seeing thereby, the noble metals are penetrated so much, that not the least of an ignoble sort can escape the action thereof, but must needs be discharged and expelled: and what a degree of mutual action and re-action must there not besides happen among the *pyrites*-particles themselves, either in the course of a roasting, or of the incoction itself?

With much more propriety may the question be urged; when *gold* is procured from *pyrites*, where, by the common proof, there is none at all, or in contradiction to it, an overplus is found: instances of which I could alledge from my own experience. And from hence we learn, if nothing else, at least here to distinguish what is possible in nature: and I have repeatedly said, that it is both possible and feasible to assist nature by means of *additions*, but not without labour and expence: yet after all the good hints I have here and there dropped, for working *pyrites*, minerals, and metals in this view, I cannot omit adding something further: as that the gold educed in the common way

way from *pyrites*, is never formally in it; seeing no one single metal is ever formally in any ore as such, or can be said to be in it in its metallic form.

Gold and silver can never be called *formal*, till they have attained their metallic form, and are thus become native, or, as we speak, *grown*; but the metal is to be considered in the ore no other than an earth, which either the sulphur, the arsenic, or both together, have penetrated, dissolved, and drank up; or which appears barely in the form of an earth or stone, without any observable sulphur or arsenic.

But now is this *gold* and silver earth, or calx, an actual metal? or more distinctly, does it already possess whatsoever is proper both to its ground-mixtion and metallic form? Must something be given to it, or taken from it? We have examined this above, on occasion of Becher's and Homberg's experiments; being much the same question, as might regard a metal reduced to an earth by art: and I must needs abide by Geoffroy's conjecture in opposition to M. Lemery: namely, that for the metallisation of a metallic earth, something, namely, a fatty, inflammable matter, must be incorporated therewith.

But lastly, how will the case hold with such *gold-earth*, as by peculiar ways and *additions*, must be educed from *pyrites* and other ores? There it lodges neither formally, nor in its ground-mixtion, but must first, by the operation, be reduced to a *gold-earth*. Yet there lodges somewhat, as a meal, in the ore or metal, which only wants a proper ferment, and a due degree of coction; and this ferment again is an earth. This earth appears to be

be in the silver of the *pyrites*; particularly from the consideration of the above-mentioned experiment of M. Homberg.

Yet, first, in regard to the origination of silver from *pyrites*, there remains the same difficulty, to account for the origination of *gold*. Again, we find, that where the most silver, there the least *gold* lodges: nay, the richest silver-ores, as the *glassy*, and *red-goldish*, contain not, at least with us, any the least *gold*; whereas the contrary would necessarily happen, if not always, yet generally, were silver as such, the mother of *gold*, or did silver contain the proximate matter of a *gold-earth*. And though native *gold* may lodge in *glassy* ore, it follows not, that this ore is the soil proper to *gold*; seeing matters, as has been often observed already, may, without the one lie near, nay, lie entangled in each other, being the cause or origin of the other.

Whence then are we to fetch our new-born *gold-earth*? To ascribe it to the iron in the *pyrites* seems improbable; as the pure *iron-pyrites* neither yields any gold, by the common proof, nor admits of any melioration from additions. To suppose it lodged in the copper of the *pyrites*, can with as little probability be imagined; for, tho' *gold pyritæ* are usually coppery, yet the *yield* in gold is not always in the proportion of the copper-yield; but the richest *copper-pyritæ*, and which on that score are called copper-ore, I have always found to come shortest in *gold*.

Of the crude, unmetallic earth in *pyrites*, we know not the nature and properties, except what I myself have negatively advanced about it, and its vitrescibility; no one else, so far as I know, having ever examined it, or once dreamed of its existence

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in *pyrites*: nor is it so very easy a matter to come at the knowledge of it; as it is with difficulty, or not at all to be exhibited in a separated state, without any new mixtion.

Indeed, *gold*, as an earth, may lie in earths: and it is probable, that metals generally have their ground-earths from crude earths only, and attain their specification, or formality, from the nature of the *influent*, and the mutual action of the matters, and from the beds and matrices, their proportion and incidentality: in particular, *gold-earths* readily lodge in marly, quartzy, sandy, and consequently in vitrescible earths: so that this crude earth of *pyrites* bids fair to be a fitly appropriated soil for such conception and growth.

As to the efficacy of sulphur in that case, there certainly lies concealed great virtue, both in the whole and the several parts of sulphur, communicable by the operation; particularly in the metallic or copper portion thereof, which, according to Poppius's experiment, is capable of being volatilised and sublimed.

But, (1.) sulphur is not to be considered so much in a passive, as in an active capacity; not as receptive, but as impregnating.

(2.) I have experienced its activity, when properly applied to the incomplete, particularly the white metals and the semi metals, exerted more for the production of silver. Arsenic remains to be considered, which in this case, especially in conjunction with copper, is of some consequence: in it lodges an earth, a mercurial virgin earth, eminently suited for *gold*; as those but a little conversant with Mercury must allow; to which nothing

thing comes nearer in nature and virtue than arſenic. And I would fain know why, or whether by chance it happens, that the native *gold* in the ore of *Goldeſthal* is never found near the yellow, but always near the white *pyrites*, nay, immediately ſitting, and, as it were, glued thereon; and again, why found in *quartz* among *ſhiver?*

This *gold-earth*, which *pyrites* and other ores yield, as a formal *gold*, muſt doubtleſs be in proper weight and meaſure; and that, ſhould it belong either to the ſilver, the copper, or arſenic, not all the ſilver, copper, or arſenic, would turn to a *gold-earth*, but in a certain proportion what is fitted ſo to do. Whence I draw the following concluſion, compriſing all I have hitherto ſaid, and which deſerves to be obſerved: that if this meaſured or proportioned quantity of earth be already proximately prepared, and ſuch a *gold-earth*, as only, like a *gold* reduced by art to an earth, wants the fatty proportion to its metalliſation, it is educible by ſeparation in the common way of proof, without any further treatment: but if not an actual *gold-earth*, but muſt firſt be reduced to ſuch; we cannot in that caſe ſay, *pyrites* holds *gold:* and ſhould more than two different parts of *pyrites*, nay other foreign matters employed, contribute to the ground-mixtion of ſuch *gold-earth*, we muſt the rather adopt the terms, *introduction*, *production*, *tranſmutation*, *&c.* and drop that of ſeparation.

It need not be wondered, that I have dwelt ſo long on this queſtion, as it includes another; *viz. whether art may not become aſſiſtant to nature?* And ſo far as this laſt regards not only a matter of truth, but of utility too, ſo far does the other deſerve to be

be examined into and cleared up. But ſhould it at length appear to be a thing impoſſible to enrich ores and ennoble metals, this uſe at leaſt we may reap from it; *viz.* to learn not to throw away our labour and time to no purpoſe: on the other hand, ſhould we find ſome degree of melioration attainable; this would not only encourage us for the preſent, but be an incentive to us for the future to proceed further.

CHAP. XIII.

Of the ORIGINAL PARTICLES, or of the PRINCIPLES of the PYRITES.

WE have hitherto treated of the mixed and compounded parts of the *pyrites*, as (1.) its iron-earth; (2.) copper-earth; (3.) crude, unmetallic earth, with which the two firſt are ever entangled; (4.) its ſulphur; (5.) arſenic, and the ſandarach thence procurable; (6.) the ſilver; (7.) the gold in the *pyrites*; all theſe are to be found in the *pyrites*, though not in equal regard or conſideration, ſome being eſſential or conſtituent parts, others incidental only, and without which the deſtruction of the whole either may, or may not be effected. The proper ground-parts are an iron-earth, and ſomething that is volatile, and that either ſulphur or arſenic; all the others, namely, the copper, gold, and ſilver, are incidental, as the *pyrites* is often found to be without them; but as the proportion of the copper is often found to exceed the iron-earth in weight, it is neceſſary to take a view of it in another light: yet, as the copper riſes and falls, nay, may be quite wanting, it might indeed be removed from the claſs of incidental, and brought nearer to the firſt order of parts; but to diſtinguiſh it in ſome meaſure from the parts, both of the firſt and ſecond order, it may be aſſigned a middle rank, and be called a ſecondary conſtituent part of the *pyrites*.

What

What we now propose is, in short, to learn what particles the iron, copper, crude-earth, sulphur, arsenic, gold, and silver in *pyrites* consist of. Speculatists, ever fond of enquiring into what is called the principles of things, may be apt to think we should have set out with, instead of having postponed 'till so late this enquiry. These preposterous enquirers into nature, ever at the entrance upon their disquisitions, fall to explaining the principles of their subjects, before they have once duly examined their mixt parts, much less their forms, proportions, habitudes, connections, divisions, productions, &c. To lay so great a stress on things quite out of the reach of our senses, as principles, in truth, are, and overlook what our senses are proper judges of, is but the high road to endless conceits and imaginations; one single proposition, fairly deduced from experiments, being far preferable to, and more valuable than all those imaginary theories, which have neither experiment, nor other solid foundation for their support: and though it may not be unuseful to reason about things, yet we should proceed in such a manner, that the reader may be led, as by a clue, from the proximate to the remote principles, from the mixt parts to the simple, and thus in a retrogade order, namely, that in which we treat the subject under experiment.

Now, if we would take all the parts educed from *pyrites* in the largest view possible, these either existed already in the mixtion thereof, and thus are actually separated, or are new-produced in the act of separation, or rather of the destruction of the *pyrites*, or else they existed in the *pyrites* in distinct parts; the former are iron-earth,

copper-earth, crude-earth, ſulphur, arſenic, gold, and ſilver, all which we have again divided into eſſential and incidental parts: of the latter, or the parts new produced, we have only one inſtance, namely, vitriol; yet it may be queried, whether to this laſt ſort might not be added ſandarach, as ſulphur and arſenic, whereof ſandarach conſiſts, eſſentially and corporally exiſt in *pyrites*, not in an united, but a ſeparated ſtate, though not coming up ſo fully as vitriol to the caſe. And it might be further queried, whether the gold and ſilver in *pyrites* were actually, or corporally and formally, tho' in a ſeparated ſtate therein, and not new produced, eſpecially by means of *additions*.

Should we abide by the eſſential parts of *pyrites*, namely, the iron, ſulphur, arſenic, alſo the copper, the *pyrites*, in the ſtricteſt ſenſe, is not a *mixt*, or a body made up of ſimple parts; nay, not a *compound*, or a body put together of *mixts*, but a *decompound*, namely, put together of *compounds*; and accordingly the queſtion ſhould ſeem, not to regard the original particles of the *pyrites*, but the original parts of each part of the *pyrites*: but as this would carry us too far, and eſpecially as I conſider not theſe parts as ſuch, but only as parts of the *pyrites*, we not only may, but muſt enquire into its original particles, as a compounded body; and *pyrites* being a *decompound*, the queſtion is, whether the compounds, as the ſulphur and iron were actually and formally preſent when the *pyrites* was formed, or whether theſe compounds firſt exiſted in the act of formation and production; or, what to many may appear more diſtinct, whether the formation of the *pyrites* be a *compoſition*, or a *mixtion?* where, by the former, the parts muſt actually exiſt, but by the latter firſt begin to exiſt.

We

We are here not to consider nature under the notion of a builder, who collects and prepares his materials, but rather as forming *mixts*, in the course of the composition itself; or, in the course of the decomposition, *compounds*; and, in the course of the formation, forming new materials, not existing before; and even by means of destruction, which readily happens not without new productions; though some, from experiment, might maintain the contrary: as it must be allowed, ore may be prepared and formed by art, from parts already mixt and compounded, as metal and sulphur, yet no consequence can be drawn from art to nature; though, so far should seem probable, that nature and art may proceed in the very same manner: and I have made several experiments, in the view of mineralising metals, which I shall here communicate.

A proper ore consists, proximately, in a metallic earth, sulphur, and arsenic (either one, or both together, of these two volatile matters) to which may be added a frequent admixture of an unmetallic crude earth; I mean such a crude earth as is incorporated with the mineralised metal, or proper ore mixture, and not a kind of stone and mineral adhering to the ore: I also do not mean ore in a lax sense, according to which, all sorts of stone, barren in metal, sulphur, and arsenic, are called a mineral, or ore: nor do I mean ore in the usual notion of miners, who stile silver-holding *yellows* and *browns*, ores; but I intend such, where the metal is plainly and eminently seen mineralised, or reduced to an ore-state: or, ore in the strictest sense, is either a *sulphurated*, or *arsenicated* metal, as *pyrites*, lead-glitter, copper-ore, tin ore, *red-goldish*, *glassy* ores, and the like.

When I would try to make ores from metals, and, as it were, re-produce them, I cannot, for that purpose, employ the principles, or simple particles themselves, of which they are formed by nature in the bowels of the earth, as these, in their separated state, are no objects of our senses; but I am obliged to use metallic earths, or formal metals, also real sulphur and arsenic, in order either to *arsenicate*, or *sulphurate* the former, and thus bring them to the form of an ore. In some instances I have hit tolerably well, in some but indifferently, and in others not at all, as will appear from what follows.

(1.) From some universal earths, which neither are, nor were actual ore or metal, metals may be made; for instance, from fossile calamy, iron, indeed in no considerable, and zink, in a large quantity; not only when the proper body, wherein it may incorporate, namely, copper, is exposed to it, but even without the addition of metal, barely upon the application of the metallising, fatty matter, with proper care and attention, that the matters be not burnt out and reduced to ashes.

(2.) From metallic earths metals may again be made, and, in part, such as they already were, as from lead-ash, tin ash, &c. lead, tin, &c. namely, by re-incorporating the fatty, metallising substance, or *phlogiston*, which operation is called *reduction*; partly, what they were not before, as sufficiently appears both from gold and silver, which may, in different manners, be educed from different incompleat metals, and semi-metals, particularly, bismuth, tin, regulus, lead, and quicksilver.

(3.) From

(3.) From universal crude earths it is with difficulty that ores can be exhibited, the contrary of which one might be apt to imagine from the opinion of such earths being the *mother* of ores, and the sulphur and arsenic with their coction, the *father*, or impregnating principle. Examine the matter, as I have repeatedly done, but in vain, with sulphur, a thing otherwise powerful and efficacious, on well purified and prepared ochre, which already, along with sulphur, was an ore, that is, a *pyrites*; or if you suspect it fallen, by the vitriolisation, to a form quite irreducible and foreign to the design, take slime, marl, loam, clay, and leaving out the tenderest, unchangeable, and mildest earths, try any how, with sulphur, to accomplish an impregnation of ore: though it cannot be denied, that to the production of metals, particularly of iron and silver, by means of sulphur, not only the earth of one of its parts, namely, its fatty portion, but of its whole substance, is really fitted; as, by a due degree of appropriation and incalescence, it is not only made operative, but, by a proper length of time, may be made permanent; but this last operation requires the hand of an able master.

(4.) From some metallic calces, or earths, that were actually metallic, ore may be again made, as appears from the genuine *glassy* ore, which, from the saline silver-calx, when smelted along with sulphur, nay, softly, and for a continuance thoroughly warmed therewith, usually appears in a *drusy* form.

(5.) From silver itself, without previous reduction to an earth, there is again procurable with the addition of sulphur, or rather cinnabar (as the sulphur

in

in the cinnabar has more time duly to lay hold on the silver) such a glassy ore, not easily distinguishable from a native sort; as appears from the known cinnabar processes, where usually filed silver is cemented with cinnabar.

(6.) Ores may be made from the incomplete metals, and from semi-metals, as tin-ore from tin and sulphur, antimony-ore from regulus and sulphur, bismuth-ore from bismuth and sulphur, cinnabar from quicksilver and sulphur, lead-ore from lead and sulphur, namely, where the sulphur is in separate parcels, conveyed on the metals in flux; and that the incorporated sulphur may not be forced off again, the mixture is poured out in due time. Yet,

(7.) It is from the fewest metals such ores may be made, as shall resemble those from which metals were originally smelted, *viz.*

(8.) A factitious tin-ore, which is flakey, blackish, sooty, and stellate, like antimony, nature no where supplies us with, though properly to be called a sulphurated tin.

9. From tin (so far at least as I have tried) no tin-ore can be made; neither can its proper mineralising substance, the arsenic, be brought to flux, and consequently to the requisite degree of activity; nor the tin duly exposed and appropriated to it, on the score of its easier dissipation and incineration. As little,

(10.) Is a mineralised bismuth, or factitious bismuth-ore, found similar to a native; for, though it appears smutted by the sulphur, and looks fine, yet

yet it not only does not exhibit the texture, but even the appearance of the natural mixtion is wanting, by which it ſhould hold no ſulphur; though this experiment ſhould, on other accounts, be repeated, and more accurately examined.

(11.) That procured from lead and ſulphur comes tolerably near a foſſile lead *glitter*, or ore; only it is very ſmall-grained, and, if not removed almoſt inſtantaneouſly from the fire, proves very ſooty and powdery.

(12.) The reduction of a metal to the form of an ore, even its native form, is better ſeen in antimony, which is procured from regulus and ſulphur, but more fine-grained than a foſſile antimony commonly is; and would certainly be more coarſe-grained, if art, like nature, could take the proper time, and the operation not be hurried.

(13.) 'Tis in the preparation of cinnabar, that is, the mineraliſation of quickſilver, that art, at length, moſt perfectly approaches to nature, inſomuch, that between a factitious and a native cinnabar, very little, if any diſtinction appears.

(14.) On the contrary, copper cannot be mineraliſed, or not ſo as to be like a native ore, for that procured from ſulphur and burnt or calcined copper *(æs uſtum)* is no longer a metal, only as it contains ſulphur, it is called a mineraliſed copper; and, after burning out the ſulphur again, nothing remains but a metal burnt out, and reduced to an earth; And where in nature do we find ſuch a ſort?

(15.) No

(15.) No genuine ore is procurable from iron, especially in the form of a *pyrites*; for, as to the factitious *pyrites*, for which antimony is employed, it is in parts highly antimonial, and thus of a mixtion unlike what is native, seeing antimony is never observed to be in *pyrites*; or, it will be a sort of scoriæ, or slags, where the iron, after the precipitation of the regulus, combines along with the sulphur, and exhibits something resembling an ore, without appearing yellowish, like an ore consisting of iron and sulphur, as in the *sulphur-pyrites*. Besides, in the absence of the salts it falls not to pieces, but remains firm and lasting; and yet it is affected by the air, though not in the way of vitriolisation, such as the air usually effects in genuine *sulphur-pyrites*. We come still nearer to nature here, when for the sulphuration of iron, instead of antimony, we employ a pure lead-ore, under which operation lie concealed some practical truths.

Now it is possible there may be some better means of bringing metals and metallic earths back again to their native ore-form, as the ways of trial in nature are so endless, that it is not possible to devise, much less perform them all; we must not therefore, from a miscarriage in an intended experiment, directly conclude the impossibility of the thing: yet it follows not, that nature, in her formation of the *pyrites*, proceeds in the very same manner that art does; but, from the circumstances hereafter to be alledged, there is no small probability, but that to the ground-work of *pyrites*, as of other ores in general, not *mixts*, but *simples* or principles contribute; that is, not matters already proximately prepared for parts of *pyrites*, but undetermined

determined juices and damps, which, by their conflux and coction, first of all become either iron-earth, copper-earth, sulphur, arsenic, gold, or silver, as now extant in the prepared *pyrites*.

Upon a general view of the subterraneous ore-productions, particularly *druse* and *sinter*, we shall find three sorts of stone, and as many ways of their production and generation.

The first is an *induration* or condensation of dry, earthy, but tender, porous, and powdery particles, by which an earth may be baked, and become of the hardness of stone, by means of air and water, as I have reason to be fully satisfied by indubitable signs from the *ætites*.

The second is a *precipitation* of earthy particles out of water, by means of its running and trickling down, whence arise the *sinter flos ferri* and *staladites*; not out of muddy, but the most transparent spring-waters, in which the earth lies strewed up and down in the most tender manner, so as to escape not only the sight, but the closest strainers.

The third is a *crystallisation*, where stoney, both flinty and spathy particles, intimately dissolved and mixed in the water, like a salt, shoot out of the most transparent crystal waters, by means of rest, and by length of time; consequently, by the most leisurely and unobservable evaporation of the moisture into formal, saline crystals; as I have fully made appear in chap. V. In this also Dr. Woodward agrees, with respect to the production of *druse*, *mountain-crystals*, &c.

But

But as to ores themſelves, it is not credible that any one of the above three ways is that by which they are generated: to begin with the third; we find, indeed, ſuch, not only cryſtalliform, polygonal, priſmatical, &c. forms, both in ſtones and ſalts, but alſo in *druſe*, lying immediately on ſtone and bottoms, formed by cryſtalliſation, as might incline us to think both the ore and ſtone to be generated at once, and in the very ſame manner. But it cannot be conceived alſo, that metallic earths, ſuch as belong to the formation of ores, ſhould be ſuppoſed to be diſſolved by meer water, ſeeing we have neither example nor experiment to that purpoſe, as we have for the production of *druſe*.

Why then muſt things, lying upon and near each other, be ſuppoſed to be produced together, and in one and the ſame manner? When *ſinter* comes to ſettle, the *drifts* and ſhafts, where it is uſually produced, are not full, but empty of water; but cryſtalliſations happen not without water: and from ſight we learn ſuch apertures to be as ſeldom, after the generation of the *pyrites* on the *ſinter*, full of water, as before in the generation of the *ſinter* itſelf they could poſſibly be.

As little can the ſecond way be genuine, whilſt, as was ſaid, common water is incapable of bearing up ſuch heavy particles as the metallic are; I will not ſay in ſuch a degree of diſſolution and rarefaction, as there are no inſtances to ſupport the aſſertion, but in ſuch quantity as would be needful for the production of the ſuppoſed ore; ſeeing, by the leaſt degree of reſt, they ſhould ſeparate again like a ſlime or *ſludge*. In a word, between water and a crude

crude unmetallic earth there may, indeed, be ſome, but between water and a metallic earth, no analogy; but the latter may by means of middle ſubſtances, *viz.* ſalts, as appears from the effects of ſharp, corroſive waters on metallic earths, be appropriated to each other.

Laſtly, as little can pure induration prove of any conſequence here, if, amidſt many other circumſtances we again only conſider the beds and figures of *pyrites* on *druſe* and *ſinter*.

But there are ſome ſtrong reaſons againſt imagining the generation of an ore to reſemble the ſpringing of a plant out of the earth; one is, that then we muſt expect to find in the ſtone or rock the roots, and, by their means, a connection of the ore with other matters, as its origin; but of this we find not the leaſt trace either on *druſe* and fiſſures, where they often lie as looſe as if only glued thereon by one end, or in the firm rock or ſtone. But the generation of ores rather happens *damp-wiſe*, as I think I have ſhewn in chap. V. I ſhall only repeat one thing, that from hence, in particular, it appears, why the ores, ſtanding on *druſe*, generally preſent one ſide only, namely, where the *weather* or damp beats on them like a driven ſnow.

Theſe ore-producing and ore-conveying *damps* may, both in their original and incidental matters, not happen to be of one and the ſame mixtion and influx; yet it is not ſo neceſſary to ſuppoſe a very great variety of them, ſeeing it is poſſible, from the internal coction, the length of time, the beds or matrices, to aſſign a reaſon, why from one and the ſame damps different productions may ariſe.

The

The beds or matrices are, undoubtedly, in some degree, pre-requisite; for, though almost each sort of ore be to be met with, consequently generable in various sorts of stone and earth, for instance *pyrites*, the universality of which is indisputable; *red-goldish* ore, which is to be found on quartz, spath, shiver, &c. lead-ore, not only in these, but in lime-stone, and other minerals; tin-stone in quartz, spath, Muscovy-glass, and clays; and we are still far from having made such discoveries in the bowels of the earth, but that many more may remain concealed; nay, probably, ores may be discovered in beds where they were never suspected to lodge, in particular, quartz, horn-stone, &c. which are the firmest bodies, prove to be universal matrices of ores: yet here it holds not as of the matrices of animals, which are absolutely necessary, and contribute materially to the birth.

This is manifest from experience: however the difference of beds may contribute something to the generation of ores; for, otherwise, why should *lead-glitter* be, if not quite a stranger, yet rare and thin sown in *shiver*, whereas *pyrites* is almost universal; and why should tin-stones never be heard of in shiver? But we are not always to form a judgement of the truth of this proposition from *mixt-work*, where ores and minerals are seen mixed together in a surprising manner; but then it is in places where two very different veins happen to cross each other.

In like manner, superfoetations must not be totally rejected, particularly, where ores and minerals are disposed in layers, one on the other; and where, not the undermost stone or rock, but each layer,

layer, muſt be conſidered as the matrix of the next above it. Beſides, it is not to be denied, but that there are beds, or rather productions, where, according to all appearance, the under and over layer contribute neither poſitively nor negatively to the production of *pyrites*; that is, neither promote nor hinder it, but the *damps* contribute all; nay, even to the firſt earth of Becher, and thus to the ground-work of the ore.

Leaſt of all is nature to be here conſidered as a common mechanic, who has all his materials ready prepared, and only puts them together: for, tho' the *gurs*, or mineral juices, and *ſinter*, among which are claiey and ochry matters, are, and may be matrices, yet ſuch marly, ochry mineral juices muſt not be ſuppoſed to exclude other earths and ſtones.

In a word, ores certainly have a matrix; firſt, a fitly adapted place; again, a matter not quite dead and motionleſs, but emitting its efficacy and emanations on ſomething, or at leaſt is a receptive matter. In and upon ſuch earth and ſtone may ore and metal be produced, but neither can ſuch earth or ſtone themſelves turn to ore or metal; which matrix, whether the ſtoney or earthy, contributes more material damps, is a queſtion not ſo eaſily reſolved: the anſwer, however, ſeems to favour the laſt more than the firſt; as what is tender, ſoft, and yielding, is more fitted for the change happening here, than what is cloſe, hard, and ſtoney.

But in all theſe *out-weatherings*, or exhalations, either from the under or upper layers, either porous, ſlimy or cloſe; that is, either earthy or ſtony

matrices, the affair principally depends on the *inweathering* or inhalation, for the production of an ore, particularly *pyrites:* which *inhalation* only consists in damps, fumes, vapours, *&c.* seeing, from the consideration of *druse* covered over with *ore* and *sinter*, neither induration, precipitation, crystallisation, nor vegetation, can have any place.

These damps are mineral, yet not of an ore and metal mixtion, but, proximately, fitted for such a mixtion. They must be of different forms and mixtures, consequently of different powers and virtues; as the business of mineralisation cannot depend on bare coction, or the nature of the matrix or bed; namely, subtile earths, which, in certain places, proportions, times, degrees of warmth and coction, become in one place lead, in another tin, *&c.* and when once prepared, remain unchangeably the same, tho' indeed subject to *weathering* or destruction.

In general, mineral damps have the following origin and nature; they proceed from all manner of bodies, either animate or inanimate, though from the former in greater plenty; not only from porous and loose bodies, but also from the closest and heaviest bodies, even from firm stone, of which we have an instance in the magnet. Some bodies or matters evaporate, barely by a diminution and dissipation of their entire substance, as pure water, volatile salts, brandy, camphire, phosphorus, *&c.* Other bodies evaporate by an abstraction and separation of their highly subtile particles from the more close, coarse, and earthy parts; for instance, a saline or earthy water, either spontaneously or artificially. Others again exhale, by a destruction both of their texture and mixture; as appears

pears from the volatile salts procured from the corrupted parts of animals, and the acid of beer. This destruction is in the vegetable kingdom called *fermentation*; in the animal, *corruption*; and, in the mineral, I find no better term to express it by than *weathering*, or dissolution.

The matters considered as exhaling, are either purely watry, as pure water and brandy; or watry-earthy; as wine, beer, vinegar, oil, and slimy, saline, and bituminous waters; or earthy-watry, as wood, bones, gums, salts, sulphur, bitumen; or lastly, almost pure earth, if not entirely earthy, as crude and metallic earths, stones, ores and metals.

Now, as evaporation is a kind of motion, and motion implies an impulse; we here find as impellents, air and fire, which must animate, as it were, and make natural mixt bodies evaporate, or they would otherwise remain at rest and motionless. Air certainly is a capital instrument in the business of evaporation, as being of itself not only sufficient, but better fitted for the purpose without actual fire; whereas fire cannot subsist without air: and the dissolutions, malaxations, separations, purifications, and new productions, *&c.* by means of air alone, prove quite different from those procured by fire. Yet air, which is in itself cold, and neither at all times attempered by the sun, nor by a particular sort of weather and wind, may be aided in its effects, when you would have it a proper, efficacious instrument, if not by an actual fire, yet by a due screening. The air operates from within outwards, whereas actual fire only externally: air also takes up more time, and thus makes purer and more lasting parts. It, indeed, carries along with it foreign

matters, but ſuch as are more tender, flowing, and ſimple than the coarſe, ſooty, ſtubborn, and earthy particles of fire, which in open or chinky veſſels mix more of the flame with the ſubject. The principal effect of the air here is by its tenderly mixing the ſubtile, dry parts with the moiſt in a cloſer manner than can be affected by the fire.

In regard to mineral damps, particularly thoſe for the formation of the *pyrites*, three things are to be conſidered.

(1.) Of what they conſiſt.

(2.) Their origin, and the manner of it.

And, (3.) How they become *pyrites*.

As to the firſt, namely, in what the *pyrites* damps conſiſt: we are not to ſuppoſe the univerſal air-particles, as the proximate matter and ſeeds; ſeeing this would be going too far back: neither on the other hand, are we to conclude them to be ſuch mixtures, wherein the parts of the *pyrites*, namely, the ſulphur, arſenic, iron, &c. are formally and ſubſtantially contained. But rather taking the mean, to ſuppoſe them to be damps of a middle ſubſtance, not common to all the three kingdoms, nor formal parts of the *pyrites*, but a kind of fatty, tough glue.

Here we muſt readily allow, (1.) That the proximate and firſt ſeminal forms of the *pyrites* may conſiſt in crude unmetallic earths.

(2.) That crude earths are in their mineraliſation and metalliſation, primarily appropriated to iron, and

and secondarily to copper; as by destruction these two metals are usually very easily reducible to such earths; not but that they may degenerate (tho' not become of another species) from the unkindliness of the soil and other circumstances. And these damps are to be considered as different as the several *pyritæ* themselves are, and as universal as the *pyrites* itself is.

As to the second thing, namely, whence these damps, or the seeds of *pyrites* arise; we have three things to consider here.

(1.) Dry bodies, as earth and stone; only the parts of the former lay spongy and loose on each other, but those of the latter baked firm; and, at times, seem as if run or melted together: whence stone may be produced from earth, and earth again from stone. Now the question is, whether these last exhale.

We have three sorts of stone; namely, marl-stone, lime-stone, and flint-stone. Marl-stone, which has ceased to be an earth, and commenced a stone, not only crumbles in the air, but proves a good manure for vegetables; various instances of which I have mentioned in my *Flora Saturnizans*; particularly, one from Oberau in Misnia, which sufficiently shews the affinity between the vegetable and mineral kingdoms. But for this stone to contribute any thing to the growth of plants, it must be resolved, whereby the resolving moisture of the air does not so much crumble its earth, as rather extract something from it; not take it up as a fine powder, but swallow it up in such a manner, that the earth, by means of the water, is no longer an earth, and as little a water, but a third kind of

glutinous ſubſtance, ariſing from earth and water; which by vegetables is drank up in the way of a vapour: and the ſame matter, in order to ſerve to the growth of ores, muſt have both its firſt riſe and propagation vapour-wiſe.

Crude, unburnt limeſtone ſeems alſo ſubject to *weathering* or reſolution, and in the ſame manner: the *ſtalactites*, *dropſtone*, or *ſtone ſinter* of *Friberg*, to which the *iron-blooms* are alſo referable, is a ſort of lime-ſtone. This limy ſubſtance is derived from a tender earth, ſuſtained and carried along by pure water, from which it ſeparates in proper time and place, and falling down collects gradually, and turns to the hardneſs of a ſtone. Now, as the water lets it fall, it is plain, it is ſomething incidental to it, and ſomething that it muſt have licked up ſomewhere in its paſſage. A like inſtance, not a little confirming this opinion, we obſerve ſometimes on walls, plaiſtered over with lime, as in large aqueducts; for inſtance, that called the *halſebrucke* at Friberg, and in thoſe arches built in mines for ſtrengthening *ſhafts* and *levels*; where it evidently appears, that the *ſinter*, hanging down from theſe walls, comes from the lime; or rather, that the lime, even after being burnt, ſlacked, and no longer quick and capable of conception, is, notwithſtanding, ſtill fitted for reſolution, and capable of being abſorbed by the water in the tendereſt manner; only with this difference, that this *wall-ſinter* is not near ſo firm and hard, but remains always very ſpongy and flaky. Now, here we cannot ſo very expreſly aver, that ſuch earth is looſened by a *weathering*, and afterwards incorporated with the water; but that this rather happens, as we muſt at leaſt allow of *wall-ſinter*, by means of a ſoft flooding; tho' in regard to the genuine groove-drop-ſtone, from its particles being ſo intimately mixed with the water,

ter, as by a kind of extraction, there must be a weathering or resolution to precede the flooding and extraction. Yet, amidst all our uncertainty about this matter, we observe lime-stone to be subject to destruction and resolution, from which come highly subtile earths, which, as here, may change to a formal stone, and in other circumstances, to different other productions.

The nature of *quartz*, or flint-stone, seems entirely impregnable and lasting; yet those *druse* and *quartz*, which appear, as if gnawed and nibbled by mice, seem to admit our calling their indestructibility in question: and, I must own, this sort of stone may contribute something to the production of ores, as it is so eminently adapted for that ground-earth, called the stony and vitrescible, by Becher.

(2.) In the depths of the earth we have collections of slimy, sulphureous, and saline waters, whence damps, vapours, and exhalations may arise, which may greatly contribute to the production of ores; from an internal incalescence and fermentation, as it were, these matters exhale, and in conjunction with other vapours, become proximately adapted for the generation of all manner of minerals.

(3.) Ores themselves exhale, of which we have palpable instances, tho' my experience extends only to four sorts, which exhibit any such change on the surface of the earth.

But this is not required of all; seeing (1.) several sorts of ores may be produced, tho' not several bodies, *weathered* or resolved for the purpose: as the resolution of a *red-goldish* ore is not requisite to the production of an ore of that sort, but a quite dif-

ferent fort, according to circumſtances, may be produced from the damps ariſing from this ore.

(2.) As in the bowels of the earth, quite other cauſes and circumſtances may concur, by which all ores, and ſuch as we find unaffected at the day, may become ſubject to *weathering*.

Now the four, hinted at above, are alum-ore, cobald, biſmuth-ore and *pyrites*. Cobald, when expoſed long in the heap, either in a cloſe, damp, moiſt room, or to the open air, rain and ſun, eſpecially in ſmall pieces, or a meal, becomes ſo heated, as to emit a ſharp, ſweetiſh damp or vapour from it. Hither alſo biſmuth-ore is referable, which not only generally adheres, but is alſo nearly allied to ſmalt-cobald, and uſually bewrays its *weathering* among cobald, with an efflореſcence of a peach-bloom colour. Alum-ore, particularly the ſort of a woody original, and ſtill containing woody matters among it, and of a bituminous nature and quality, as the large alum-mine at Commodau in Bohemia, which takes fire in the air, after lying a little expoſed on a heap in the weather and ſun; ſo as not only violently to fume, but alſo turn to a coal, and burſt out into actual flame; for which reaſon it muſt be often daſhed with water. Stone-coal, ſo far as it is genuine, and not conſiſting in bituminous, light, aluminous matters, has not, ſo far as I know, the ſame effect as this alum-ore. And the queſtion is, whether ſuch accenſions in coal-pits are ſpontaneous, or heedleſsly cauſed from actual flame and fire.

Limeſtone appears, as was hinted above, even in its unburnt ſtate, to be fitted for *weathering*, and to bear ſomething to be extracted from it, communicable, if not to the air in form of a damp, or vapour,

pour, yet to the water, running over it. Again, it ſhews, that in calcarious hot-ſprings, it may be burnt by ſubterraneous fires even in the bowels of the earth, and thus communicate itſelf not only to the intercurrent waters, but probably, as in ſlacking quick-lime, may emit a ſaline, earthy fume, fitted here and there, eſpecially with the acid of other vapours, for all manner of mineral productions.

Pyrites is, preferably to all other ſorts, capable of manifeſting the ſubterraneous *weathering* of ores; yet the white, or poiſon *pyrites* is incapable of any ſuch ſigns in the bowels of the earth, or by any experiments in the huts, like what we obſerve of the yellowiſh and yellow. The coppery ſort, it is true, will not eaſily fume or exhale at the day, unleſs it be made very ſmall, and lie expoſed in large heaps in a proper place to weather and ſun. But the coppery waters in the grooves, having their original only from reſolved *pyrites*, ſhew alſo that *copper-pyrites*, eſpecially in the bowels of the earth, and under certain circumſtances, is liable to deſtruction or reſolution.

Theſe waters, which are commonly called *cement-waters*, are not only obſerved at Neuſol in Hungary, but alſo in many grooves with us at Friberg: and it would ſeem to me, that the more coppery the *pyrites* are, in which caſe we at Friberg uſually call them *copper-ores*, not *pyrites*, the leſs yielding they are to ſuch *weatherings*, and the firmer and more conſtant they remain; whereas the leſs copper the *pyrites* happens to hold, and the purer they are in iron, it more eaſily vitrioliſes; beſides, that we have fewer inſtances of ſuch vitriolic waters, but many of ſprings, holding pure iron-

iron-vitriol; as the *iron-pyrites* is not only the moſt common ſort of *pyrites*, but of ores too; ſo that, preferably to other minerals, it ſhould ſeem to be ſerviceable for yielding fumes and damps for the production and generation of new ores.

3. Some other circumſtances are here to be conſidered, by which we may have a nearer view of the manner of *pyritification*, or mineraliſation in general.

(1.) We are not to imagine theſe ore-damps, which at length end in the form of the *pyrites*, already to contain the parts of the *pyrites*, as iron, copper, ſulphur, and arſenic, but only to conſider them as a ſeed. This is matter of fact; the proof clearly appears from the enumeration of the ſeveral circumſtances above, therefore I ſhall only mention the texture of this ore, which is ſo ſmooth and even, ſo undiſtinguiſhable, ſo uniform in the mixtion of its parts, as if run or caſt together, and hence in its ground-work, of the moſt tender mixtion, and ſuch a form, as can never be imagined of damps, containing the parts of the intended whole, without forming too groſs a notion of the mineral principles.

Yet this compariſon of animal and vegetable ſeeds muſt not be carried too far, as if the body of the *pyrties*, grown from its ſeed, could from its own ſubſtance enlarge and encreaſe: but here happens, first, an accumulation, in the courſe of which, an elaboration commences at the ſame time; by means of which the matter gradually approaches to the intended body; and ſo long as it is ſtill receptive, or if you had rather, ſeminal and ſoft, ſo long it ſtill receives the tranſient damps, which

which it brings into the ſame ferment and coction with itſelf; and when the body begins to be compleated, which happens from within outwards, it ceaſes to receive any thing further, till at laſt it is arrived at its ſtate, or full degree of perfection, and is, as it were, finiſhed. Nor ought we more readily to believe *pyrites*, or any other ore, once arrived at their conſiſtence, firmneſs, and ſtate, to improve further; for inſtance, in gold and ſilver-*yield*, all further working is at an end, and the body continues at reſt and at a ſtand. An ore, it is true, begins again to come into motion, not indeed for its melioration and exaltation, but rather deſtruction and reſolution; as I mentioned above, and ſhall ſtill further prove in the following chapter.

What has hitherto been ſaid, may ſeem ſufficient on the head of the *original particles* of the *pyrites*; as being matters quite out of the reach of our ſenſes, and in ſupport of which we can have no convincing proofs; but the whole muſt be made out by diſtant inferences and reaſonings, and a good ſhare of imagination: nor can any very conſiderable uſe be expected from them: yet, I cannot omit taking notice of two objections, for the ſake, at leaſt, of obviating ſome prejudices, and making ſome remarks, that may not be altogether unuſeful.

(1.) It will be aſked, how water is capable of ſuch mighty effects, and the moiſture of the air, which is nothing but a pure water, of diſſolving, corroding, and *weathering* ſtones and ores? I might only, for anſwer, direct the objector to the *pyrites*, which may be ſeen to crumble and vitrioliſe barely by means of the air, without any ſharp, corroſive waters; but here I cannot forbear advancing

cing an useful truth, regarding the very mystery of the art, without engaging now in tediously enumerating what experienced men have boasted of common water, or rather, of what only appears to be such; for instance, Becher, of a water drawn off from fresh clay; Cassius, of the phlegm of aqua-fortis; others, of that from vitriol, rain, dew, and the moisture of the air; or without mentioning the power of the air, in regard to its effects on the animal and vegetable kingdoms.

This *truth* may be supported, that genuine solutions depend not so much on strong corrosions, as on gentle macerations; that is, such solutions, as shall yield us any new extraordinary productions; as it cannot be denied but that corrosive waters may yield something worth the trouble, tho' nothing extraordinary. Now, the less corrosive the means of solution are, the less of a saline nature they must hold; and the freer they are of that, the less violence they exert on, and the more they are adapted, softly and naturally, to macerate the subject; and to this we should bend our chief regards.

Thus, between solution in general, and maceration, there is a wide difference; in regard, that the latter is always a solution, but the former not always a maceration. In a solution by corrosive waters, the *solvent* and *solvend* become indeed one body, but not so closely united, as in maceration; for, by maceration, the *solvent* is so intimately combined with the *solvend*, as not only to become together an indiscernible body, but also to acquire a new form and nature. Yet the moisture of the air (tho' the offspring of other waters) has something peculiar, and should indeed seem, as it is saline, to have the effects of saline solvents: but properly

perly and formally it holds no ſalt, and if any be procured, it muſt be by means either of corruption or fermentation; and thus, by means of the deſtruction and transformation of the *mixtion*; or by means of a magnetiſm; and hence it is at various times of various forms, according to the nature of the body it happens to be incorporated withal.

The incomprehenſibility of the volatiliſation of earthy particles may be objected, againſt what muſt happen in the *weathering*, or deſtruction of ores for new productions: but here we muſt not underſtand an evaporation in an earthy form, as what might well be allowed to happen, tho' not prove of any ſervice to the buſineſs of the production of ores; but an evaporation in the way of a clammy, fatty, viſcous fume, wherein the moiſture has intimately drank up the earthy part. There may be intended in general a volatiliſation, of dry particles, either by the power of nature or art, yet we are well to obſerve, that there is a wide difference between undertaking ſuch volatiliſation with a body, as ſtanding in its natural crude union with other things, and as ſeparated from them. *Poppius* on *Agricola* has proved the preſence of real copper in ſulphur, and I myſelf have diſcovered formal iron in crude ſulphur. Have we not here therefore a volatile copper and a volatile iron? But take and try your copper and iron, and you will find ſuch volatiliſation a very difficult matter, or not to ſucceed at all; whereas ſuch metals, whilſt ſtill lodged in *pyrites*, volatiliſe without any art, barely by the act of deſulphuration; and nature may carry on her proceſſes in ſuch places, ſeaſons, and other circumſtances, as are quite out of the power of art to command. To come nearer to our ſubject, we know

know the principles of the *pyrites* to as tolerable a degree of certainty as is possible, but to pretend to shew them in glass-bodies or cucurbits, and thus resolve the *pyrites* into these principles, and make them the objects of our senses, is what I despair of ever doing.

I am, however, apt to think, my notions about the *original particles* of *pyrites* and ores in general, may go as far, if not farther than those other principles; namely, salt, sulphur, and mercury, æther, and air, globules and *striæ*, or acid and alcali, *&c.* As to running mercury, tho' no metallic principle, yet I believe it procurable from *pyrites*. Mr. *Boyle* tells us, that some choice English marcasites being worked, in order to assay them for gold and silver, did, without any mercurial *addition*, yield some mercury *. This may well be matter of surprize, as it may be what does not always happen: but, when I come to consider arsenic, as a substance certainly mercurial, and that it only wants to be made fluid, I see nothing uncommon in all this. I shall say nothing of the acid salt of sulphur, as what, among all the volatile things, comes the nearest to quicksilver.

We have also experiments of some mercury being procured from oil of vitriol. Now arsenic lodges in almost all *pyrites*; in a large quantity in the white; in a less proportion always in the yellow, and often in the yellowish. Probably, the above marcasites were yellowish, as the yellow do not so readily appear marcasitical, that is, cubical: and the white, tho' such a figure be not uncommon to them, are not commonly called marcasites. And probably, the yellow and white may be fitted for mercu-

* Boyle on the producibility of the chymical principles.

mercurification. But, whether the arsenic, after separation from the *pyrites*, that is, in arsenic-meal, fly-stone, or crystalline arsenic, be fit for this purpose, I leave those to determine, who consider incidental circumstances and appropriations, as so many empty notions, and who understand not the importance of the difference between bodies, as still in their native mixed state, and as in their separated.

With respect to the question, whether sometimes ore-veins may be found, where the ore-production is in *fieri*, and not actually formed: if this be understood of the accumulation of ore, there is no manner of doubt, but that ore is produced on ore; and a vein, a fibre, may be so filled up as to receive neither this nor any other sort of ore-damp; and thus the vein, that hitherto was but in *fieri*, comes now to be compleat. But ore is certainly generated, and that *damp-wise*; but damp-wise productions imply surely an accumulation. But should the question regard the ground-mixtion of the ore itself; the most experienced can neither shew the places and nests, where the ore-forming spirit broods, nor the ore in its eggs and seeds. Further, neither can the *gurs*, or metallic juices, whether from destroyed *pyrites*, *weathered* ores, or from macerated, luty, marly, slimy, spathy, and calcarious stones and earths, claim any place here. And tho' in this case our want of experience is to be lamented, yet it is probable, that after all our enquiries, we shall find neither eggs nor brood, but be forced to own, that *pyrites*, and all other ores, do in the course of the conception, or of lodging the ore-damp in its matrix, arrive to their perfection by a speedy coction and maturation; if the accumulation itself be not the mixtion.

CHAP.

CHAP. XIV.

Of the VITRIOL from the PYRITES.

THE title of this chapter may, to many, appear ſtrange, particularly to thoſe who hear mention made of *vitriol-pyrites*, in contradiſtinction to *ſulphur-pyrites*, as we allow not *vitriol* the title of an eſſential, conſtituent part of *pyrites*, but only a new production from it. *Vitriol* is, indeed, a body formed from *pyrites*, its parts, though not united in the form of *vitriol*, exiſting in the *pyrites*, and forming *vitriol*, without the acceſſion of any other foreign body: for, though *vitriol* be not uſually produced without the action of the air, yet the two eſſential parts of *vitriol*, namely, the ſulphur-acid, and the metallic earth, actually exiſt in the *pyrites*. This *vitriol* production commonly happens in the very ſame proceſs whereby the ſulphur is procured, though it uſually happens without any deſulphuration, even ſpontaneouſly: but as many *vitriol* productions have deſulphuration for their proximate ground or baſis, ſo as not well, nay, not at all to happen, eſpecially at the *day*, without the former following it, the buſineſs of *vitriols* cannot well be omitted, eſpecially as it gives much light towards a better knowledge of the nature of the *pyrites*; though I cannot be ſo full and explicit as I could wiſh, for want of proper experiments, and can now only touch on the principal matters, reſerving a fuller account of this incomparable metallic-ſalt for another opportunity; I ſhall, therefore, with all the brevity

vity poſſible, conſider three things, (1.) the nature of vitriol, (2.) its kinds; (3.) its production, from all which will plainly appear the juſtice of my title.

(1.) *Vitriol* conſiſteth abſolutely in an acid ſalt, and a metallic earth, both which are, by different methods, to be procured from it; the principal of theſe I ſhall only touch on.

Under the acid ſalt we are not to repreſent to ourſelves ſomething dry (and yet, what is ſulphur more than a concentrated *vitriol*-acid?) but ſomething fluid and aqueous; though the dry form of acid ſalts be no impoſſible thing, having, in an uncommon manner, ſhewn it from ſpirit of nitre and ſpirit of tartar, for exhibiting a pure, acid, dry, volatile ſalt. It may be ſeparated from its *vitriol-mixtion*, either, as is uſually done, by diſtillation, at firſt coming over in a white aqueous form, called *ſpirit of vitriol*, then in a thick, heavy, yellowiſh, and ſomewhat earthy form, under the appellation of *oil of vitriol*; or procured by means of an intermediate, namely, a lixivious, body, whence ariſe the known medicinal ſalts, *tartarus vitriolatus*, *arcanum duplicatum*, *ſal mirabile Glauberi*, &c. with this remarkable difference, that it is not again to be forced out of the alcali, in the ſame manner as from the metallic earth, without becoming again, by means of a new intermediate body, a formal ſulphur; when it exhibits either a *ſpiritus ſulphuris per companum*, or a *vitriol* again; as from ſulphur it ſuffers itſelf to be incorporated with a metallic earth.

Next to ſulphur and *vitriol*, it lodges chiefly in alum, in which it has received its body from a

fatty, bituminous mineral; as may be seen, in particular, from the woody alum-ores of Commodau, the shivery ores of Schwemsel, and the earthy of Belgern; but, as appears from its resolution, alum possesses it in a quite unformed, white, stubborn form, most probably referable to a calcarious sort. It sometimes acquires, in distillation, a foreign, either a vegetable or animal fattiness; as, when in the course of the operation, the vessels happen to have cracks, through these the fattiness insinuates into the work from the fumes of the wood or coals, or when with design something inflammable is added, and then 'tis called *spiritus vitrioli sulphureus*, as the acid *vitriol* salt, and the phlogiston, exhibit therein something sulphureous.

The metallic earth of the *vitriol* is procured either by means of distillation, and remains like a brown-red powder, a *caput mortuum*, at the bottom of the retort; to which head also belongs the calcination of *vitriol* in other vessels, and for other purposes: it may also be obtained by means of precipitation, which is performed by an alcali, but, at the same time, earthy particles precipitating out of the alcali, a pure metallic *vitriol-earth* is not procured.

In this earth, after distillation, something lodges that may be extracted with hot water, and has the form of a white salt, called *gilla vitrioli*; not to be considered as a third constituent part of *vitriol*, nor as the *vitriol* itself employed, but as something different, a more elaborated, and thus a whiter *vitriol*; in regard it, in part, still consists of the same acid salt as was already drawn off from *vitriol*, and also it contains a portion of metallic earth, for

for the most part coppery, whence it is used as an emetic, and called *vomitoria*; I shall not assert that its contents are also somewhat aluminous, having not examined it thoroughly, though I have often suspected it.

That the *vitriol-earth* is metallic, and this always without exception, its metallisation clearly shews, as being performable by addition of inflammable, fatty things, nay, often happening spontaneously; when, for instance, the retorts, in the course of the distillation of *vitriol*, happen to have cracks, through which the fatty, fiery particles mix with the earth, which is in the highest glow, and thus fitted or appropriated, actually refund a degree of metalleity, and form an iron, as once happened to myself from a certain *vitriol*; the iron not only appearing by the magnet, but to be shewn corporally.

The proportion of these two parts in *vitriol* is generally the same in all, namely, in a pound of a fresh uncrumbled *vitriol*, commonly from ten to twelve loths, and thus full a third of metallic earth; four loths, or about an eighth of acid salt, or highly rectified oil of *vitriol*, including what is collected from the gentle evaporation of the spirit, and from sixteen to eighteen, that is, a compleat half water, or phlegm, not omitting what is wasted by the foregoing open calcination, or rather drying, in the air.

The reason of their inconstancy in the yield of metallic earth, is to be ascribed either to the difference of, or admixtures in, the *vitriols*, or to the evaporation and coction of the *vitriols* themselves; since many *vitriols* possess a copper and iron earth

at the ſame time, and that, occaſionally, in quite different proportions; but *iron-vitriol* and *copper-vitriol* do not agree in one and the ſame yield of metal: and 'tis well known, that cryſtalline ſalts, when paſſing through ſudden evaporations, and quick cryſtalliſations, are always more watry than others, worked ſlower, and more leiſurely; and theſe laſt, as being cloſer, more ſaturated, and rich in colour, are prepared by dyers, and the like ſort of people, eſpecially if coppery.

The form or nature of the *vitriolic* texture and cohesion, is perfectly ſaline, and therefore *vitriol* is juſtly called a *ſalt*, and, to diſtinguiſh it, a *metallic ſalt*; for, when pure and freſh, it appears tranſparent; moreover, it is on the tongue a ſaline, ſharp taſte; laſtly, it is not only the being perfectly diſſoluble in common water, ſo as the water ſhall remain clear and tranſparent (unleſs the air and warmth happen to dry it up, when ſuch a ſolution is apt to let fall ſomething undiſſolved, and the water to remain a ſmall time turbid) but it alſo paſſes with the water, in its entire mixtion, quite through the cloſeſt ſtrainers.

Yet, under the title of a metallic ſalt, we are not here to include a ſort, parable, or rather ſeparable from metals themſelves, without the addition of any thing foreign, and conſequently without the ſulphur-acid, a diſtinction fully made out by Dr. Rothe, in his diſſertation on *metallic ſalts*; neither are we to judge of it by the ſtandard or ſcale of acid and alcali, as in the artificial exhibition of *vitriol* from its acid ſalt and iron, there uſually happens an efferveſcence and incaleſcence by means of theſe two parts: nor can we admit, that becauſe alcali's efferveſce with acids, all bodies

dies manifesting such an effect with acids, as metals do, are and must be alcali's.

True it is, acids stand opposed to alcali's, and are of a quite different mixtion from them; but let us only represent to ourselves the incalescence happening, under a due treatment, between quicksilver and leaf-silver; here we have neither acid nor alcali, and yet the union happens with an effervescence: and what is still more remarkable, no such effect appears with filed silver, which is equally a silver with the former, even though the same quicksilver be employed; so that we see this effect is only owing to external, mechanical causes, the silver being beat thin, becomes the more exposed to the action of the quicksilver, and thereby rendered more receptive, as the latter may, with more quickness and briskness, lay hold on the silver, and thus, from a sudden brisk action and re-action, an incalescence must ensue, which in a slower degree thereof cannot.

The appellations given the several parts of *vitriol* seem in general proper. The acid salt, which commonly appears in a fluid form, lodges either in a water, and then it is called *spiritus vitrioli*, or in a thick liquor, and then called *oleum vitrioli*, or it is sulphureous, when it gains the appellation *spiritus vitrioli sulphureus*, or *volatilis*, or it still lies at rest in a metallic earth, and then it is denominated *gilla*. Now here the several appellations exhibit something different, and so are neither superfluous, ambiguous, nor equipollent.

The *vitriol-earth* is either yellowish, or of a brown-red cast; the yellowish is, either a *sulphur* or *orange*-yellow. The *sulphur* yellow is, in the first

place, both what precipitates in the boiler, and what afterwards falls down before and in the act of cryſtalliſation, alſo what precipitates from the re-cryſtalliſation of a *vitriol*; though none of theſe properly deſerve the name of an earth, or ochre, as they ſtill retain much acid ſalt; and further, ſuch earth as ſpontaneouſly precipitates from *pyrites*, particularly the arſenical, or white ſort, after corroſion or maceration by ſharp waters. The *orange*, or yelky yellow, is principally found in the earth in chinks or clefts, under the names *gur* and *finter*; alſo in many ſprings, particularly the medicinal, in *thermæ*, in *vitriolic* or acid waters; and from *vitriol* itſelf, when not burnt quite to a redneſs. Hither alſo is referable, on account of the name, foſſile ochre, or *mountain-yellow*; this yellow earth, uſed for colouring, containing alſo ſomething of a *vitriolic* earth; hence it alſo yields ſome metal, but ſuch as is not derived from *vitriol*.

As to the *red* earth of *vitriol*, it is called the *caput mortuum* of *vitriol*; not as if it was quite *yieldleſs*, ſince it not only contains the above *gilla*, but alſo metal, and that plentifully; but rather, as by the ſtrongeſt degree of fire, it is deprived of its ſaline, ſapid parts. It is now, as it was long ago, called *colcothar*; others denominate this *vitriol-earth*, *copper-red*; ſo far indeed not unjuſtly, as *vitriol* is commonly called *copper-water*, or as copper appears red, tho' not fundamentally enough, in regard this *copper-red* is often an iron-earth; and though it were a copper-earth, yet the former is always a beautiful red; the latter, on the contrary, a dirty and black red, nay, uſually appearing entirely blackiſh. Further, it is called *red vitriol*, or *atramentum rubeum*, but as it is only in part, and not entirely, it deſerves not the appellation, *vitriol*;

ol; though others would by it underſtand, not a thing burnt, but a foſſile matter, namely, a red *vitriolic* mineral, and would mean by it the *chalcites* itſelf, though not ſo properly to be called a red *vitriol*, as a red *vitriolic* mineral: we alſo find it called *rubrica*, which is to be diſtinguiſhed from the *rubrica fabrilis*, or *ſcriptoria*, [ruddle] uſed for drawing and writing.

In ſhort, the higheſt acid in nature, and a metal, are what conſtitute *vitriol*; the reſolution thereof evinces this truth plainly enough, and the compoſition confirms and puts it beyond all doubt.

Vitriol bears a great many names. *Vitriolum* ſeems to be derived to it from its glaſſy tranſparency and ſplendor. *Atramentum* is another appellation formerly much uſed. *Chalcanthum* was the common name among the Greeks, denoting properly a *copper-vitriol*, or rather, flowers or efflorеſcences from *copper-pyrites*, or ores, under which they muſt needs have compriſed the *ſideranthos*, or flowers of iron, or rather the efflorеſcence of *iron-pyrites*, as they made no expreſs mention of *iron-vitriol*, tho' in fact, the latter is more plentiful than the other, and its *pyrites* vitrioliſes ſooner. Such are the moſt common appellations of *vitriol*.

(2.) Under the head of the kinds of *vitriol* we find a great deal of ambiguity, confuſion, and contradiction, from the ſeveral appellations, *Sory*, *Miſy*, *Melantaria*, *Chalcites*, *Atramentum*, &c. which authors give us as the names of ſo many diſtinct kinds. *Miſy* is ſaid to be a yellow *vitriolic* concrete. M. Lincke ſent me, from the Hartz, a ſilken-yellow, clear, flakey, powdery matter, under this title, conſiſting, indeed, of martial *vitriol*,

but in itself, or rather its flakes, containing somewhat of a foreign earthy nature, which, for want of a sufficient quantity of it, I could not properly examine. As to the *etymon* of the word, I am apt to think it derives from Mysia, a country in the lesser Asia, and denotes a Mysian *vitriol*, and that its first description was taken from something external and incidental, namely, its yellow colour. *Sory*, doubtless, derives from Soria, or Syria; and as the first *vitriol*-ore from that country appeared externally, in its roughness and matrix, of a dark-grey, its description was founded on that circumstance. *Melanteria* should, from its etymon, seem to denote a black *vitriolic* concrete. *Chalcitis* is, by some, held to be a red, by others, a white *vitriolic* concrete, and really is no other than a woolly and capillary sort, and consequently a white efflorescence. Now, it is true, we have such efflorescences of a real white colour, and that on a red mineral, whence *chalcitis* is denominated red, and this is the genuine white *vitriol* mentioned by Lohneiss; seldom found any where, and with us at Friberg, not at all.

But we are to guard against taking it either for the *trichites*, or capillary *vitriol* in general, which only appears white on account of its tenderness, but which, by a due crystallisation, plainly enough shews its green colour; or for the aluminous efflorescences, appearing among and near *vitriol*, on aluminous, *pyrity mixt-work*, as is that of Braunsdorff: moreover, writers seem to mean by the *calchites* a a *vitriol* calcined to whiteness. But the prevailing opinion is, that among the ancients it denoted a *vitriolic* red mineral. But whether white or red, native or artificial, it must needs have been an iron, and not a copper *vitriol*, as having been used in making their mithridate.

In ſhort, all the abovementioned are certainly *vitriols*, and *vitriolic* mixtures, though no one of theſe titles is properly expreſſive of their nature, all of them meaning only ſomething incidental. *Chalcitis*, in its proper ſignification, which yet is not the common, ſhould denote a copper-ore, or copper-ſtone; but being now deſcribed from its earth or ſtone, and its red colour, it is, inſomuch, referable to the incidental deſcription of the others.

As to *ſory* and *melanteria*, I find ſuch *pyrity*, *vitriolic*, dark grey *ſhiver*, not only in the grooves, but alſo at the *day*, after having lain there expoſed for ſome time. Hither alſo may be referred the *vitriolic-ſory*-earths from other places; though under this appellation, Galen only mentions a firm ſtoney matter; as M. Berger *, in his treatiſe on the Carlsbad waters, mentions ſuch a ſort ſeen at Siena in Italy (ſo alſo does Matthiolus, in his commentary on Dioſcorides †) and compares it with the *vitriol-earth*, near Schmiedeberg in Saxony: and as to *miſy*, we find it often repeated, that *ſory* changes to *chalcitis*, *chalcitis* to *miſy*, not only by Caneparius, but alſo by others; by *chalcitis* not meaning a crude, red, *vitriolic* mineral, but the *vitriolic* efflореſcence itſelf. 'Tis true, a black *pyrity* mineral gives forth a white *vitriolic* efflореſcence, which, at length, turns yellow: nay, a *vitriol*, whether naturally green or blue, does, by means of a warm air, or a ſoft fire, not only crumble to a white powder, but alſo this powder, both ſuperficially, and at laſt throughout, turns of a yellow caſt; 'till at length, by heightening the fire, it is all changed to a red powder.

Yet

* Bergeri Commentat. de Therm. Carol. p. 107.

† L. v. c. 74.

Yet this *gilding* happens not ſo well in the groove, as at the *day*, unleſs there happen to be there dry places, or warm weather. From the Rothe-grube, at Friberg, I have procured much of this black-grey *vitriolic* mineral, where, indeed, the *miſy*, called the uppermoſt zone, or layer *(zona ſuprema)* of the *atramentum metallicum*, was always wanting, but ſoon appeared again, upon expoſure, for a little time only, in ſome degree of warmth. And at Braunſdorff, a mile from Friberg, I have taken up a black ſhivery rock, in which I have obſerved both *chalcitis*, called the middle zone *(zona media)* and *ſory*, called the under zone *(zona infima)*; nay, after repeated elixations, being kept for a few weeks under cover, it was again found over-caſt with white and yellow, but with this difference, that it proved a good, or, generally, a pure *iron-vitriol*, as was that from the Rothe-grube abovementioned, in the open air, not ſo much yellow, as white; but if mixt, as was that of Braunſdorff, and in particular aluminous, the yellow ſoon ſhews itſelf in the ſame air as that in which I lay the piece from the Rothe-grube: but in a warm room, eſpecially if placed near the fire, *vitriols*, whether of one ſort or another, pure or mixt, do, at laſt, all of them turn yellow; nevertheleſs I have not been able to obſerve any orpiment, conſequently nothing arſenical in what ſo eaſily, even in the cool air, as that of a cellar or vault, turns to *miſy*, though I have carefully examined it, as many others, and I myſelf at firſt might imagine; eſpecially as the Braunſdorff *pyrites-work* readily does, and is really very arſenical, of which hereafter, in particular, when I come to examine the queſtion, whether arſenic contributes to the *vitriol*-maſs, as ſuch.

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The *atramenta*, atrament-ſtone, or atrament-ore, in a lax ſenſe, denote all ſorts of *pyrites*, ſo far as they yield *atrament*, or *vitriol*, for making ink, or a black colour; but in particular, a certain mineral, or ſtone, in which *vitriol* formally lodges, only intermixed with earth or ſtone. M. Linck has furniſhed me with two ſamples of it, the one from the Rammelſberg, the other from M. Baier, profeſſor at Altorff, which indeed differs a little in colour from the former, though it may be allied to it. Both of them not only yield a *vitriol* directly in water, but alſo entirely crumble to a brown-red earth; yet whereas the laſt ſort tinges iron of a copper-red, but the firſt does not exhibit the ſame appearance; and whereas the former manifeſts ſome alum, the latter, none at all; and whereas they are properly not a ſtone, but a concrete, rather of *vitriolic* earth, as appears from their falling to pieces in water, it will be no ways improper to ſuppoſe them a hardened earth, and either formed from *weathered pyrites* entirely, or, from the *vitriolic* waters, derived from *pyrites*.

Vitriol may be claſſed (1.) with reſpect to its internal eſſence or nature (2.) its colour and form, (3.) its origin, (4.) its uſe.

(1.) As to its eſſence, or nature, it always has for its baſis a metallic earth, and that either an iron, a copper, or both together; of theſe, either ſeparately or combined, with the conjunction of the ſulphureous acid, vitriol conſiſts: if of iron, it is called an *iron-vitriol*; if of copper, a *copper-vitriol*; but if of both together, it may properly be called a *mixt vitriol*. To this laſt may be referred the *white vitriol*, which, beſides its portion

of

of iron and copper, seems, though I cannot positively say it does, to partake of something aluminous. We have few instances in the grooves of a pure, simple, either martial or venereal, *vitriol*; and when we would have it pure, the most careful methods of refining, evaporation, and crystallisation, must be employed; or, which is the surest method, the *vitriol* is to be prepared originally from its metal, either iron or copper: and that, both from the nature of the *pyrites*; not only in themselves, or as *vitriol matrices* in their mixtion (as being seldom pure irony, though the iron generally predominates, nay, is often the only metal in them, and a *copper-pyrites*, even that sort, on account of its rich copper-yield, called a copper-ore, is never without iron) but also from the nature of its encompassing rock and stone; in particular, the black, fatty, and shivery sort, as matrices of the *pyrites*, wherein there is generally, at the same time, alum generated: whence also the famous Hessian iron-earth is not always naturally pure in iron-*vitriol*, but often yields actual alum, which must carefully be parted from the *vitriol*.

(2.) Though this first classing of *vitriols*, with respect to their essence, might seem sufficient, yet it may not be amiss to take some notice of their colours, seeing these first strike the eye: these, exclusive of the white *vitriol*, may be reduced to a green, or a blue, the green martial, the blue venereal; the former is very pale, like a pale emerald, commonly called a grass, or sea-green, and ought not to be confounded with verdegrease, the colour of which is a much higher green, somewhat inclining to a bluish cast, especially when prepared by art from copper and a vegetable acid. The blue resembles a beautiful sapphire and a lasul-stone, as

this

this last has, doubtless, its origin from it, as we must necessarily conclude from certain characters and signs it affords. Now as iron and copper, as is before observed, may chance to be united together in a *vitriol*, it may be easily supposed, the colour peculiar to each metal, as green to the iron, or blue to the copper, may be in one case exalted, and in the other lowered; and one become a greener *vitriol*, the other a paler, one combined with something coppery, the other with somewhat of an iron-earth. The white *vitriol* particularly deserves mentioning on this occasion, as it has its denomination absolutely from the colour; yet, by no means, are we to imagine it a species entirely different from the blue and green in its ground-earth (as these are among themselves) seeing it is always coppery, and its white colour is to be derived from something incidental, if not from an aluminous earth, from the nature of its mixtion.

Vitriol might also be classed according to its different forms and figures, and the rather, as there are names to that purpose already extant; *trichites*, capillary *vitriol*, which often, like wool, hair, and threads, encompasses the mixt or ore-work; *Stalactites*, drop-*vitriol*, in form of icicles; *Cupæ rosa*, as usually settling, in the course of shooting, on the edges of vessels, like so many roses and flowers.

The external, or rather, occasional cause of the origin of *vitriol* affords a further distinction deserving our regard. The internal formal cause of vitriolisation shall be enquired into below, and is in all *vitriols* so far one and the same, as there is in each sort a metal-earth for its ground or basis, and the highest acid in nature, from what quarter soever

ever it come; nay, both the combination of these two parts, and their proportion, are the same in each: but so far they differ, as this acid salt is derived from different quarters, namely, sometimes from sulphur, which in *pyrites* lies next to the metal; sometimes from the air, being attracted by the desulphurated, nay, repeatedly elixated earth, as by a magnet; sometimes also, without sulphur, it is formed only by the medium of fire, as we experience in that extraordinary body, *calamy*; sometimes a prepared *vitriol*-oil itself comes to be incorporated, in the common manner of solution, with a formal iron.

From all these circumstances to select only the most general; *vitriol* is produced either spontaneously, or by art, and accordingly we have a twofold sort, a native, and a factitious. But, first, we are to avoid here the being misled by the term *waxing-troughs*, used in the *vitriol*-huts, in which troughs, as the workmen say, the *vitriol waxes*, or grows; since 'tis only a shooting, or crystallisation of a *vitriol* already *waxen* and generated, only still contained in a large quantity of water, which is to be boiled away. Many also imagine grown or native *vitriol*, which *breaks* vein-wise in firm entire rock, such as is the Hungarian sort, to have something extraordinary in it, compared with that usually formed into icicles, or flakes, in old mine-works, though both are originally derived from dissolved *pyrites*, and differing in nothing from that generated at the *day*.

The several appellations, *vitriolum coctile*, or *vulgare*, *concreticum*, *stalactites*, *stillatitium*, *cuperosa*, *trichites*, *leucojon*, or rather *lanchoton*, or *lanceatum neophyton*, *diphryges*, *magnesia vitriolata*, &c. do

do not denote a difference in the thing itself, but only a different method of production or preparation, or something incidental, *&c.*

Vitriolum stillatitium, *stalactites*, *stalagmites*, or *drop-vitriol*, signify only the figure of this metallic salt, in icicles, jags, and flakes, such as is to be found in mines, like a froze-water, or an ice; also such as usually settles in the pans, trunks, and vessels of the *vitriol*-huts.

Vitriolum concreticum, or *condensatum*, according to Dioscorides and Galen, is that procured from *vitriolic* groove-waters, by a spontaneous evaporation in the open air. Caneparius, from Dioscorides, alledges the concreted not to be so good as the *drop* sort, but this may be meerly incidental, as one sort may happen to be more saturated, and richer in colour; another, more watery, consequently poorer; but even this last may be heightened in virtue by a more slow evaporation and shooting, as by this means salts come to acquire more of compactness and body.

Vitriolum coctile, or *vulgare*, boiled or common *vitriol*, is the sort elixated with water from *vitriolic* ores, earths, and stones, particularly from *pyrites*, and procured from the lie by boiling and crystallisation, as is the usual way in the *vitriol-huts*. 'Tis called *vulgare*, as being what is commonly sold, and at an easy rate; also, as it yields another boiled vitriol, which may be called *artificial*, or prepared by art, namely, from a metal, and a *vitriol-acid*, which must needs be right pure and fine, and, on account of its costliness, really uncommon; though in fact this distinction be immaterial, as all saleable *vitriol*, with us, is prepared by elixation

tion and boiling, conſequently by art, and a genuine *groove-drop-vitriol* is ſomewhat rare.

Neophyton, a virgin *vitriol*, which, and the *trichites*, are a grown or native ſort, either in the *groove*, or at the *day*, from *pyrites* opened by the air, without an actual fire.

Diphryges is a term of conſiderable ambiguity, yet not without a meaning; this, if not purely *vitriolic*, is yet either mixed therewith, or derived from the matter whence *vitriol* itſelf generally derives. From the etymon of the word, it ſhould denote ſomething *roaſted*, which makes it probable it ſignifies a burnt or calcined, not a crude mineral, or *pyrites*: or, the term may be derived from Phrygia, and ſo denote a *pyrites dephryges*, or a *pyrity*, *vitriolic* ore from Phrygia.

Leucon, whence *leucojon* is derived, ſhould, doubtleſs, denote a white *vitriol*. Mercati and Salmaſius hold the term to ariſe from a paſſage in Pliny miſunderſtood, where, with Dioſcorides, ſhould be read ΛΟΓΧΩΤΟΝ, *lanceatum*, and not *leucojon*, to denote a *vitriol* ſhot into needles or lances, conſequently of affinity with *trichites*.

There ſtill remains another claſs of *vitriols*, which though little or nothing relating to their eſſence, is yet adopted by many, eſpecially druggiſts, dyers, &c. as the Cyprian, Hungarian, Roman, Engliſh, Saltzburg, Admond, Geyer, Goſlar *vitriols*. But not to mention, that the veins of *vitriol-ore* may break ſhort, and change, and a new ſort of *vitriol* may perhaps be procured, unknown before in that particular place, the dealers in *vitriol* keep up theſe diſtinctions only from ſelfiſh views.

The

The nature of the climate seems not to contribute much to the mixtion of this metallic salt, so far as that the one sort need be preferred to the other. The *vitriol-acid*, whether from sulphur, or the air, proves every where one and the same, as all sulphurs are fundamentally the same; the iron and copper, though, in regard to their admixture and working, they may differ according to the different places and times, yet equally lay themselves open to the action of the acid, without communicating any the least foreign admixture. Moreover, it may easily and often happen, that a country shall yield more than one sort of *vitriol* at a time, and how shall these be distinguished by the common name of the country?

Under the appellation Cyprus *vitriol*, there is now-a-days sold a blue venereal sort, though, possibly, never from Cyprus. The Roman is properly martial, and somewhat venereal, but, by fining, becomes an *iron-vitriol*. As the times alter, so with them also change the methods of working in a country; nature either refusing to afford any more materials for the purpose, or art finding it more profitable to employ these for other ends; for instance, instead of an *iron-vitriol*, to make a *copper-vitriol*, and *vice versa*, or both at once. The Hungarian fossile, or *atlas-vitriol*, is the only sort, which here, for a certainty, in some circumstances, displays something peculiar, as that among the native sort, it may hitherto be eminently called Hungarian; I say, *in some circumstances*, not indeed in regard to its mixtion, in which it is not singular, but in regard to its origin and *finding*, as *breaking* usually in firm entire rock, whereas other *groove-vitriols* are found in *shafts*, in the sides and roofs of

U *levels*

levels and *drifts* only, and therefore lying open; I have alſo ſaid, *hitherto*, as the like ſort may, ſome time or other, happen to be found in other parts, when the former will, in courſe, have its abſolute name limited.

Thus long have I detained my reader with a relation of ſuch circumſtances as regard *vitriol* only externally, and yet I muſt add ſomething more, before I proceed to the principal part of this ſmall eſſay, in order to obviate any doubt and miſconception that might ſtill remain; namely, that the term *vitriol* is alſo employed for other metallic ſalts, beſides thoſe of iron and copper, ſilver, lead, and quickſilver, alſo tin and gold; yet the two latter bear ſomewhat more difficultly the being reduced to ſalts, which may be, and by many are called, *vitriols*; as *vitriolum lunæ*, *ſaturni*, &c. But as ſuch *vitriols* are prepared only by means of the ſalts from nitre, common ſalt and vinegar, which muſt be greatly inferior to thoſe in *vitriol* and ſulphur; therefore, not by means of the higheſt ſalt in nature, or what has reſerved to itſelf the iron and the copper for ſolution.

Tho' the *vitriol-acid* may ſeem to enter into ſome bodies, particularly quickſilver and lead, eſpecially after as due a degree of appropriation as poſſible, yet not in ſuch meaſure or proportion, as it is lodged in an iron and copper *vitriol*, which employ a very large quantity of acid; but in a quickſilver or lead calx, thus diſſolved, or rather only ſomewhat corroded, ſcarce any at all is required, nor is it neceſſary they ſhould be in ſuch a degree of union, as in a tranſparent *vitriolic* body, which may be ſuppoſed to be more cloſe and tender than ſuch a calca-

calcarious earth, as vitriol-oil reduces the white metals to, and wherein not so much as a saline or *vitriol* form can be exhibited; nor in such a colour, as that in a quite surprising manner appearing in the unparallelled green and blue *vitriols*, never producible from other metals by their appropriated salts, except from bismuth-ore; where, under peculiar encheireses, or treatments, not only a genuine *vitriol-green* appeared, as M. Linck and I myself found, but also from my own small experience, a genuine purple and blood-red: nor has hitherto at least, what Caneparius, after the ancients, relates, been sufficiently verified; namely, *that each metal does in solution shew its own peculiar colour*; especially if we are willing to ascribe the blue to the silver, and can prove this from a blue silver solution; though it be certain, this blue colour ever proceeds from some small share of copper in the silver; it never appearing, if we only run this silver ore over again to its metallic body, and refine it with nitre in the crucible, especially in the case of a coppery lead, and a cold fulmination in the act of cupellation.

I know not, whether to call it an unguarded, or rather an undistinct way of expressing himself, when he pretends, an *iron-vitriol* is distinguishable by a brown-red; a *copper-vitriol*, by a green; as here he must certainly mean, not the *vitriols* themselves, but the *vitriol-waters*; and then indeed an *iron-vitriol-lie* appears of a brown-red; and yet, when pure, it is at first of a beautiful green; and a *copper-vitriol-lie* seems, but yet is not, really green. But, as iron and copper appropriate to themselves the sulphur-acid, to the exclusion of the other metals, so they not only quit these their native solvents, but also submit to others; a very remarkable circumstance, and deserving our closest atten-

tion, is, that they not only diſſolve in the grand natural acid, but alſo in aqua-fortis, ſpirit of ſalt and vinegar, tho' indeed not with that intimacy of union as happens in the former caſe, ſeeing verdigreaſe, which is prepared from copper and wine-vinegar, or the like vegetable acid, and a *vitriol*, which may be made from it with ſpirit of ſalt, are by far not to be compared to a *copper-vitriol* prepared with ſulphur. In ſhort, under the appellation *vitriol*, when without any adjunct, ſpecifying its metal, we are never to underſtand any other than a ſort prepared either from iron or copper, or both together.

3. Of the production of *vitriol* from the *pyrites*. This is the laſt and moſt important head of enquiry; though indeed, it is not ſo perplexing as the external deſcriptions from the names, figures, and kinds of the *vitriol* were, ſeeing truth is conciſe and intelligible, and writers having touched but ſparingly on this head, it is leſs confounded by ambiguities and contradictions. We ſhall for the preſent drop the white *pyrites*, becauſe it is never known to yield any *vitriol*; and confine our remarks only to the yellowiſh and yellow ſort; which, together with their proper metal-earth alſo, poſſeſs ſulphur, by means of the acid ſalt, of which, the *vitriol*, as a new production, ariſes from ſuch earth. In the important buſineſs of *vitriolisation*, we are particularly to attend to the inſtruments or means; and as theſe are two-fold, we have a two-fold *vitriolisation*, or reſolution of *pyrites* to conſider. The inſtruments are air and fire; ſometimes the one, namely, the firſt alone; ſometimes, and that oftneſt, both together; at leaſt the ſecond is not generally ſucceſsful without the firſt.

(1.) As to the air, it produces its effects both in the groove and at the day; *pyrites vitriolising* not only

only in veins laid bare, but alſo in firm, cloſe vein-ſtone; if only the ſmalleſt fiſſure happen to give entrance to this penetrating, inſinuating body; and laſtly, in mineral and *pyrites heap-work*, which is either ſhot in trunks, or otherwiſe remains lying in the groove. The firſt may be manifeſtly obſerved from a view of ſuch veins laid bare; the ſecond, not only from *vitriolic groove*-waters and *cement-waters*, as they are called, which, according to all circumſtances, muſt have their *vitriol*, not from the contiguous, but from diſtant and cloſe vein-ſtones: alſo from many day-ſprings, ſuch as ſeveral medicinal ſprings are, which, in places where mines were never worked, carry *vitriol* along with them out of the earth: the laſt we experience very often; as I have had plenty of ſuch *pyrites* from the Rothe-grube, which I have examined on account of their ſpontaneous *vitriolifation*.

At the day, or without the groove, they, in various places, become *vitriolic*, yet in ſome more than in other places; for inſtance, on that heap, or heap-work of minerals and earth, ſhot together near the groove, and ſeldom without *pyrites*; in vaults, cellars, and the like moiſt places; in rooms and cabinets; nay, on floors under roof or cover, according to the nature of the ſeaſon, the weather, and the ſituation of the building. But as the action of the air is here too ſlow to anſwer our occaſions for *vitriol* ſpeedily enough, the fire is to be called in aid; at leaſt, for the ſake of ſaving time, and on account of many *pyrites*, eſpecially the *copper-pyrites*, which very ſlowly yield their contents without its aſſiſtance; but the ſulphur, in this way of *vitriolifation*, is entirely loſt. Now, the fire is here applied in three ſeveral ways; either in cloſe veſſels and furnaces, wherein the *pyrites* is laid for procuring at the ſame

time the sulphur, as is the way at the sulphur-huts; or, out of a wind-furnace, whose flame plays on the *pyrites* lodged in an adjoining roasting furnace: or on a roasting-bed, where the *pyrites* may be best thoroughly burnt, or calcined: the first method is that used at Friberg, for the sake of preserving the sulphur.

2. The fire is the next instrument; which, if not entirely sufficient of itself, yet is serviceable for the first opening and preparing the *pyrites*, nay, indispensibly necessary for many sorts of *pyrites*, which would not otherwise shoot in the air. It is indeed of itself alone sufficient, nay absolutely needful, for exhibiting *vitriol* from other *vitriolescent* bodies, particularly fossil calamy, from which, without burning, there is no hope of success; and tho' the burnt calamy be never so long exposed to the air, yet it would not, for all that, receive the more *vitriol*; which is something equally peculiar; as is also in this very process and act of burning, the sulphur-production. The burnt, or calcined *pyrites* do also, after burning or roasting, without a previous exposure to the air, yield, by the usual way of elixation, a *vitriol*; but not generally (the reason of which difference I have not yet sufficiently discovered) nor so richly, as when the air has previously for some time thoroughly worked them: but this and a great deal more must be attentively considered.

As (1.) In what the business of *vitriolisation* consists. (2.) What is procured from it.

As to the *vitriolisation* itself, it depends on various circumstances, particularly the following. The air is the principal agent here, and contains two

two principles, (1.) An universal moisture, or a rarified water. (2.) A salt fit to incorporate into many bodies, not always in the same manner, but diversified according to the nature of the subject: whence bodies, especially the dry, become not only moist, but also more ponderous: some, particularly the lixivious salts, entirely liquate, as the *olea per deliquium* manifest; some, and even these, moreover, receive another salt, as the bitter *vitriolated* salts, separating from liquated pot-ash, sufficiently testify. Now, tho' the salt of the air, considered in itself, without at present regarding its saline nature in this or that particular place, be various; or, tho' it may differ according to the difference of the subject, to which it gives or communicates itself, yet this is a thing that cannot sufficiently be explained. However, from the just mentioned *vitriolated* lixivious salt, so much appears certain, that the *vitriol-acid* in such salts, which differs in nothing from that in *vitriol* itself, may exist, if not formally, yet potentially in the air, and be found actually and formally, as such, in these salts; as may incontestably be shewn from the genuine mineral sulphur to be thence exhibited: and thus we have in the air not only what appertains to the exhibition of a salt as such, and to its crystalline transparency, namely the water, as appears from the *vitriol*, efflorescent, or striking out on *pyrites* in bare air, without addition of any actual water; but also, what most properly belongs to the essence of *vitriol*, namely, the *vitriol-acid*; though it be only as an *ingredient* and *immanent* instrument in desulphurated *pyrites*; but in the crude fresh *pyrites*, where the acid lies still plentifully in the sulphur, it acts as a penetrating instrument.

This collective air lays hold on and attacks the *pyrites*, and without it we are never to expect any *vitriol*, not even the spontaneous *vitriolescence* of *pyrites*. For, tho' I have had no opportunity of making any experiments with the air-pump, yet I have observed, that *pyrites*, when kept in a very close glass, especially in a dry and rare air, *vitriolises* with more difficulty than without the glass: and from this gradual difference it seems, that were it possible entirely to exclude the air, a *pyrites* would with the more difficulty, or not at all, become *vitriolic*. In short, the air is entirely necessary for the purpose, and that according to all and every property thereof, not in its separate but collective nature. For that the water alone is insufficient, appears from the *pyrites* not giving in the least, tho' lying, nay boiled in water never so long; as little effect has the *vitriol-acid* alone, seeing the *pyrites* remains whole, entire, and unchanged in the strongest *vitriol-acid*; nor are both these together sufficient; the affair depending not so much on the matter of the air, as on its motion, its soft and gentle attack, its wavy ambiency and insinuating impression, in order to the accomplishing these destructions, and procuring new productions.

It has been already mentioned of white *pyrites*, that it yields no *vitriol*, tho' its arsenic, of which it principally consists, yield in some measure to the air, as I have mentioned above of the *fly-stone*: it is the yellowish, or universal *sulphur-pyrites* and the *copper-pyrites*, or the yellow copper-ore, that are properly subject to the action of the air; tho' for their improvement and exaltation, yielding slowly, and with some degree of resistance; and with this

remark-

remarkable difference, that the yellow give not at all, or with difficulty, at the day, but, in the groove very readily: for, having in various manners endeavoured to *vitriolise* the *copper-pyrites*; or the yellow copper-ore, and for that end exposed it in numerous ways, and in different places, both whole, and beat small, also in pretty large *heap-work*, both naked and covered, I could never procure any *vitriol*, though after an exposure of many years; nevertheless, I would not pronounce the thing impossible, though very difficult: and therefore I would thus distinguish the spontaneous *vitriolisation* of *pyrites*, and affirm the yellowish to be subject thereto, both above and under the earth; the yellow only under, and with the greatest difficulty, above the earth. The reason of this different efficacy of the air depends doubtless on incidental circumstances, into which we are unable, with all our art, to bring the yellow *pyrites*.

Now, it is a difficult matter to assign either a general or particular reason, why for each sort of *pyritee*, the *vitriolisation* happens either slow or quick, or not at all: for, though the copper greatly stands in the way of *vitriolisation*, yet there are circumstances and examples, wherein this does not always hold good; as I have had yellowish *pyrites* that contained no copper, and yet shooting with great difficulty, nay often not at all, into *vitriol*; of which we have many instances here at Friberg under the appellation *cobald*, or a sulphureous, arsenical *pyrites*. There are two sorts of *pyrites*; the one from Pretzschendorff, the other from the Eisrne-Schlange; the latter of which *vitriolises*, but the former not in the least, and yet they entirely agree in their small copper-yield. But what is most remarkable, there are *pyrites*, not only agreeing entirely

tirely in yield, namely, having neither copper nor arſenic, no not in the leaſt quantity, but only ſulphur and iron along with the unmetallic earth; alſo one and the ſame figure, colour, &c. yet one ſort; *viz.* that of Almerode in Heſſe, as alſo the ſort from Altſattel by Egra run exceeding quick to this metallic ſalt; another ſort, as that from Boll and Toplitz, very difficultly, nay, if not beat very ſmall, and buried in the earth, not at all. Amidſt thoſe contradictory inſtances, I have ſometimes dropped the copper, and aſſigned as cauſes, the figure, the colour, and ſometimes the texture and the grain of the *pyrites*, ſometimes again the arſenic, at other times the unmetallic earth, ſometimes the bed, and the adjoining or interſperſed minerals, and ſometimes one of theſe circumſtances only, ſometimes two or three at a time; or rather, as colours and figures are not cauſes ſo much as ſigns only of theſe cauſes; from the ſigns I have endeavoured to come at the things themſelves, and from their difference, was obliged to abide by the contents, the mixtion and texture of the *pyrites*.

From the arſenic there accrued a great degree of probability, that as the white *pyrites* does not at all *vitrioliſe*, its arſenic, according to its greater or leſs quantity, muſt at leaſt be the reaſon, why the yellowiſh often undergo *vitrioliſation*, and the yellow always with difficulty, or not at all; did not that ſort, which is without any arſenic, and yet remaining *unvitrioliſed* as the other, ſtand in the way: The unmetallic earth, which is two-fold, either flinty or calcarious, afforded no light in the caſe. From the texture, one *pyrites* appears not only denſer and more fine-grained than another, but has alſo, though no other *mixtion-materials*, yet another *mixtion-guiſe*, as well in proportion as in elaboration

boration and coction; consequently, the air may work on one sort sooner and easier than on another.

Now, tho' the proportion and manner of connection of the particles of *pyrites* may cause a difference, yet we cannot sufficiently judge of it from their apparent density and rarity; as I meet with *pyrites*, which, besides their similar nature, appear entirely of an equal grain and cohesion, though not equally subject to *vitriolisation*. From the colour it holds, the yellower the *pyrites*, the less, though not the converse; and the paler, the more ready it is to give or *vitriolise*.

From the figures, both the external and internal, as the angular, the round, the radiated, the testaceous, *&c.* there appeared some faint glimmerings of truth. Thus it holds, that the round *pyrites* *vitriolise* with more ease than the angular; and the radiated, than the testaceous. The reasons I also find in the copper and arsenic, of which, both the round and radiated are usually free.

In a word, I at length discovered the causes that now render easy, then difficult, or quite impede, the business of *vitriolisation* to be various; one cause taking place in one instance; another, in another, and often two together, often one only, and often neither of the two: now, these are copper, arsenic, and the texture, and what arises thence, the density; not to mention the unmetallic earth, concerning the difference of which we may entertain some suspicion, nor the different mixtional proportion.

Copper, certainly, is the greatest obstacle of all to this *vitriolic* resolution, when even in the smallest quantity;

quantity; and the higher the *pyrites* rises in this metal, the less it *vitriolises*; this is owing to the sulphur, which being here set free from the metal-earth, and yet again operating thereon in another manner, is held very fast by the copper, to which it adheres more closely than to iron: then the arsenic opposes together with the copper, not only in the *copper-pyrites*, but also in the *iron-pyrites* without any copper; instances of the one sort are evident in every copper-pyrites-ore, of the other sort in the Halsebrucke arsenical *iron-pyrites*.

Lastly, the business also sometimes depends purely on the texture, closeness, and grain, without any copper and arsenic, though this is the rarest case, as I learn from some periwinkle and muscle *pyrites*, consisting purely of iron and sulphur, yet without ever running to *vitriol*. Often two causes concur, as is ever the case in the yellow *pyrites*, where along with the copper, there certainly lodges arsenic: often, the business turns on one cause only, namely, the arsenic alone, or also purely on the texture alone: often, all the three concur, namely, in the fine-grained and finest sort of copper-ores: and, to conclude, we have here a confirmation of the axiom, that *one and the same effect may have very different causes*.

This difference, both in the mixtion and texture of the *pyrites*, manifests itself often in one and the same vein; where we have copper-ore and *iron-pyrites* lying in each other interspersedly; and again, *pyrites* lying like so many nuts or eggs in a shell, wherein upon breaking it some small veins and eyes of *copper-pyrites* appear. Among the Almerode *pyrites-balls*, commonly called iron-earth, and for pure sulphur and iron the properest and best

sort,

ſort, are found not only radiated and ſtellate balls, which are at leaſt of a different texture from the globular, but alſo cubical; which, in regard to their metal-earth, differ remarkably from both the former, and are not without ſome copper; though the ground and bottom, where they lie intermixed, nay compreſſed together, be one and the ſame.

In the territory of Boll, are whole tracts ſtrewed with various ſorts of *pyrites*, as the periwinkle, muſcle, nut, globe, and *radii* kind; and ſuch *pyrites* generally agree in mixtion, like that ſort in, and under the under-turf earth, and of like figures, and neither coppery nor arſenical; and yet I have had inſtances, though rarely, of *pyrites*, containing ſome little arſenic and copper, and yet produced in one neſt and matrix, near and among the former; a thing not to be wondered at, as ſuch mineral productions are ſubject to many incidents, which interupt their growth; nor is it at all ſurpriſing to find *pyrites* ſimilarly, and diſſimilarly *vitrioliſe*. The globular reſolve ſooneſt and with the greateſt eaſe; the radiated or conical more difficultly, and tho' they ſhould ſoon enough reſolve into *radii* or cones, yet they here remarkably ſtop ſhort, before they fully change to *vitriol*. The conical conſiſting of a number of cones or pyramids put together, with their points concurring in the middle, and their baſes again projecting into ſhort, either ſharp or obtuſe, and theſe again partly in broken angles; and where joined together, they are, doubtleſs, not ſo cloſe and firm, as in the remaining parts.

That the air is the genuine and abſolutely neceſſary inſtrument in *vitrioliſation* we have already ſhewn, and it may be ſummarily confirmed from this conſideration, that *pyrites*, which remain unreſolved

resolved in the bowels of the earth, do at the day, or above the earth, remarkably change or vitriolise; and that without any thing foreign, besides the access of the air, from which, under the earth, they are at least more screened. Now, here it is worth remarking, that in many sorts of *pyrites*, the *punctum saliens* of this new production acts from within the *pyrites* outwards, the *vitriol* not settling from without, but striking out from within; as sufficiently appears, not only from *pyrites-globes*, which, in their falling to pieces, generally from their middle emit genuine native vitriol, but from other angular pieces of *pyrites*, broke off from veins, and which on the side, where they are thus broke off, ever turn *vitriolic*.

Two questions with respect to the *pyrites-globes* here offer themselves to our consideration, (1.) How the air can break into such close compact bodies.

(2.) Why it does not rather eat into their circumference, and thus operate from without inwards. As to the first, the round *pyrites* in general, or such as *vitriolise* in that manner, are internally, and in their inmost parts, not so close and compact as in their external circumference; nay, have a small, an almost unobservable cavity; further, that this sort, as was observed above, consists of a number of cones or pyramids, and not only upon a spontaneous resolution, but upon the application of an external force, whilst still fresh, falls to pieces of such a conical form. Now, as it is at these *radii* or cones, issuing out from the centre, we ever observe the resolution of these cones to happen, they are, doubtless, traces of small tender fissures, or signs of the cohesion not having hitherto become so close, as these cones do not so readily

readily fall to pieces crofs-wife, as in the direction of the radii; and in thefe fiffures, the air infinuates itfelf to the heart of the pyrites-globe.

This alfo may ferve to account for the refolution of the fecond queftion: it is true, the air firft acts, or rather falls upon the *pyrites* externally, but it acts moft powerfully, when in a proper place, and at undifturbed reft; both which it finds in the centre of a round *pyrites*, which is in and about the centre, if not quite hollow, yet of a porous texture: whence the clofer a *pyrites-body* is, with more difficulty does the air not only force into it, but the lefs of it can be collected therein. And hence a piece of *pyrites*, which is now no longer a whole, nor thus to *vitriolife* from within outwards, but to be corroded externally by the air, does in the open air and laid naked there, vitriolife with difficulty, or not fo quickly, as when laid in a heap, and thus lying at reft, and in fome meafure warm: and thus the innermoft receffes of fuch *pyrites* become impregnated with *vitriol*; which burfts out by breaking afunder its fhell. Neverthelefs, when fuch round *pyrites*, as ftill lie in the earth, muft *vitriolife*, they fall not afunder in fuch pieces, but remain entire, notwithftanding which they part with their *vitriol*, either by an evaporation, exficcation, and a reduction to an earth, by an unobferved elixation, though I fufpect the former rather than the others; thus they exhibit themfelves internally neither *pyrity* nor *vitriolic*, but like a brown, yellowifh, rufty iron-ftone, or an iron-earth firmly baked together; as in particular may be feen from periwinkles, and mufcles, exhaufted of their *pyrity* fubftance; which in their fhells, ftill really exifting, though generally calcined,

cined, are often, without falling to pieces, entirely shattered and burst as by a force, evidently acting from within outwards; and this may be judged to be owing to the *vitriolisation*.

The reasons certainly are, the air's neither so briskly entering into, nor so powerfully acting upon them; in regard they lie, if not in a peculiar and firm narrow case or enclosure, as a stone, which yet is not uncommon, yet covered under the earth, and in some measure only, not entirely, exposed to the access of the air: again, tho' their shells may crack, yet their parts separate not to any distance, as being urged or pressed upon by the adjoining earth and stone; and though by the act of *vitriolisation*, they may turn to an earth, yet they must hold together, become compact, nay even petrify.

Such periwinkles and muscles stuffed with *pyrites*, or pieces of *pyrites*, of the form of periwinkles and muscles, are found cracked, rusted, and again hardened, at Boll, and the adjoining territory, in great quantities, and in various sorts; particularly, *chamæ*, *pectunculi*, *cornua ammonis*, &c. but never, so far as my experience has reached, in *lapis lyncis*; the cavity of which is nevertheless often found filled with *pyrites*, a circumstance deserving peculiar notice; and I have discovered at the Schlossberg at Toplitz a *terebratula*, entirely rusted and remaining firm; a thing I never observed before, whatever pains I took in the search.

Further, I besides remarked, that many such sea-shells, exhausted of their *pyrites*, were only externally rusted over; but upon preparing them both in their entire state and beat small, for *vitrio-lisation*,

lisation, though in vain, I found them of ſuch cloſe texture, as to render them unfit for it, either externally or internally.

Laſtly, I have had inſtances, where the bodies were thoroughly ruſted, yet neither burſt, nor fallen to pieces; but then many ſuch ſhells are not pure *pyrites*, but greatly mixed with other earth, and alſo ſtone, particularly, ſhivery, loamy, and ſpathy matters; nay, ſome contain no *pyrites*, but ſuch earths only; and, in that caſe, neither an expanſive force, nor a *vitriolisation*, but only a leiſurely ruſting, and reduction to earth, are to be expected.

Thus much of freſh *pyrites*; but that the air alſo works on the deſulphurated and thoroughly burnt *pyrites* towards *vitriolisation*, we ſhall hereafter mention, having firſt to treat of the other inſtrument, namely, fire. And here we muſt premiſe ſomething on the internal cauſality, or how the ſpontaneous *vitriolisation* of *pyrites* happens internally.

Philoſophers might readily call it *magnetiſm*, to denote a mutual action of damps and juices; on the ſide of the patient, namely, the *pyrites*, conſiſting in a *receptivity*, and on the ſide of the agent, or air, in an *influx*. Miners expreſs it by the term *weathering*, and very properly, as they uſually call air, *weather*; beſides, affirming, that we are by it to underſtand, not a deſtruction of the matters of the *pyrites*, but only of its texture or coheſion; leaſt of all are we to imagine it a reduction to its original parts, or a ſeparation, but a new production. The reſolution here produced is indeed ſo far a ſeparation into parts, as the ſulphur is abſolutely to be ſet free from its metal earth, but in that very act the

new production happens; and as soon as the sulphur is thus set free, so soon does it lay hold, with its acid or salt, on the loosened metal-earth, and therewith exhibit the *vitriol.*

Hence, in the process of *vitriolisation,* though never so attentively performed, not the least separated sulphur is to be found. Now as little as in this resolution of the *pyrites,* or destruction of its texture, the business is a separation, though this last, in some measure, happeneth; so little is the exhibition of the *vitriol* a separation from *pyrites,* as really, and in truth, to be considered a new production: for, the parts of the *vitriol,* namely, the sulphur-acid and metal-earth, are indeed in the *pyrites,* but not thus combined.

In brief, *vitriol* is as little in the *pyrites,* as brandy and a volatile salt are in the grape and fresh urine; but are all three produced from *pyrites,* must, and urine respectively, by means of *weathering,* fermentation, and corruption; and that not only by a transformation of the particles of the *pyrites,* must, and urine, but also by an actual essential influx of the particles of the air, considered above in their water, earth, and salt, and which here not only pass through, but adhere to the fresh *pyrites* and its particles, *i. e.* are not so much a *transient,* as an *immanent* instrument; as appears from the several productions and transformations in the three kingdoms.

It seems, however, probable, that air enters not so much by its saline part, as by its universal humidity, into fresh *pyrites,* for the exhibition of *vitriol.* The probability of this hypothesis may be inferred from hence, that there already adheres to such

such *pyrites* much salt, especially in the sulphur, sufficient to dose its metal-earth: and it cannot be shewn, that the least sulphur flies off without producing its effect. We are not, however, to deny the salt in the air its incorporating virtue, as it stands inseparably united with the humidity, tho' its humidity is here still more necessary, for exhibiting a true saline form, such as the *vitriolic* must have, seeing it is in no case procurable without water. And though in spontaneous *vitriolisation* the humidity of the air always manifests itself, yet other water is not to be excluded.

For, first, the former is aided by the latter, as we see upon exposing to rain, or sprinkling with water, the *pyrites*, either beat small, or in its gross state, and laid on large heaps together; *aided*, I say, and not the former replaced by the latter, as *pyrites*, when entirely plunged in water, and thus excluded the access of the air, never turns to *vitriol:* so that notwithstanding the sprinkling with rain and water, the whole business must chiefly turn on the motion, warmth, power, and influx of the air; and then also, by means of other water, larger and purer crystals are procured, and in a larger quantity. But the moisture of the air alone being employed, the crystals prove small, like grains of sand, nay, often like hairs; and thus, when the *pyrites* falls to pieces and to earth, there is no separating them from the impurities, without either washing them with water, or without elixation and a new crystallisation.

But possibly, from the nature of the grooves, the moisture of the air is not the whole, but the waters, trickling down on all sides, may wash out the tender *vitriol-shoots*, and coming afterwards to

settle a little, or otherwise evaporate, let them fall again, either in icicles, from the roof and sides of *levels*; whence we must make some distinction between *grown*, or native *vitriol*, as spontaneously produced from *pyrites*, namely, between that sort formed barely by the humidity of the air, without any addition of either day or groove-water, and that other formed by the accession of an actual water. The former we are not to expect in the grooves, and 'tis rare that it is *grown*, though shot on the spot where found: whence appears the great folly of alchemists, in that they would employ for their *great-work* that produced in the grooves by the water of the air alone, a thing quite impossible.

For the *vitriolisation* of *pyrites*, there are, besides the action of the air, other aiding or concurring circumstances requisite, at least when it is to be rendered easier, or to be more speedily dispatched. Those on the side of the *pyrites* itself, though indeed only negative, I have already mentioned, and now come to this, namely, that the *pyrites* must contain little or no arsenic or copper, nor be of too close a texture: to which we may add this conjecture, that the black vein-stone, or rock, usually called *kneiss*, at Friberg, and almost shivery, but much blacker and harder than *shiver*, is, if not a co-operating cause, yet a sign of an easier *vitriolisation*; but as to external circumstances, there are principally three, which facilitate this operation. First, and principally, the *pyrites* is to be laid together in as large a heap as possible, and to lie exposed to the weather and sun, nay, in dry weather to be sprinkled with water, as otherwise it cannot heat or work so well: or, in the small way of proof, the beating small the ore, the choice of a fit place, as a cellar, or the like warm situation, and the laying it in a powdery

powdery heap, are to be called in aid; and these failing, I know not further how to advise, when you would have a *vitriol* without fire, or the addition of any thing extraneous.

As to the other instrument in *vitriolisation*, namely the fire, its relation thereto is somewhat different from that of the humidity of the air. Such *pyrites* as spontaneously yield not to the action of the air, or too difficultly and slowly, or that must previously be worked for sulphur, are first, either roasted, burnt, or desulphurated, and this holds, in respect of the difficulty of *vitriolisation*, not only of the yellow *pyrites*, or our copper-ore, but also often of the yellowish, that is, of many sulphur or iron *pyritæ*. But here occurs a difficulty, namely, that the burnt *pyrites* must generally be thrown on heaps in the open air, though there is also a sort, from which, immediately after burning, nay, tho' still warm, a *vitriol* may be elixated. I made trial with all my *pyrites*, under the different circumstances of being much and little burnt, put warm and cold into water, but often without procuring any *vitriol*.

From the instance of fossile calamy, which, immediately upon burning, nay, whilst still warm, yielded not only a good deal of *vitriol*, but also not a little alum, I imagined the same would succeed equally well, if not better with the *pyrites*, as containing the sulphur, consequently the acid of the sulphur not only so plentifully, but also the metal-earth immediately; whereas in calamy there is little formal sulphur, consequently, little sulphur-acid; but it must first be, by means of the fire, both generated and rendered active. The *pyrites* mixt-work of Geyer, which is properly an iron-stone in-

terspersed with *pyrites*, is a sort, which directly upon burning (for it proves too poor for making sulphur) has been elixated for *vitriol*, yet with me it has not yielded enough; though the reason of such *pyrites* giving *vitriol* without air, barely by means of the fire, be, that the sulphur therein finds a prepared corporal iron, wherein its acid salt may directly lodge, yet the case is certainly different in a pure, firm *pyrites*, the iron-earth of which is not thus prepared. I have, however, procured a little of such *vitriol*, and the small share of *vitriol* from all sorts of *pyrites*, shew the possibility of the thing.

But though I could not succeed in the manner I had been directed at the *vitriol-huts*, yet I find no reason to deny that *vitriol* may be procured from burnt *pyrites*, without a previous exposure to the air, especially when I consider the peculiar experiment of the *vitriol* from calamy: besides, that from the miscarrying in the small way of proof, we cannot question the truth of the large way of working (as, in other respects, the conclusions from proofs in the small to yields in the large way, are often very fallacious) as I have experienced how difficult in general it is to assay *pyrites* for *vitriol*, without employing large heaps for the purpose.

Yet it may be made appear probable, that the air contributes something here, when we consider the nature of fire, as yielding no flame without air, nay, deriving by and from it, together with the fatty, soot-particles, its needful fuel and *pabulum*; and thus the air is at least an indispensible instrument in *vitriolisation*. But be this as it may, such *pyrites* directly elixated upon burning, when, to be further worked for *vitriol*, is to be shot in the air, and

and there to lie for some time. Upon the whole, by means of the air, a fresh *pyrites vitriolises*, air plays in amidst the burning of the *pyrites*, and, lastly, exerts its efficacy in the heap, when the *pyrites*-earth is become unfit for further impregnation, and thrown on the *slag-heap*, under the name, *caput mortuum*.

Thus the fire is, in the business of *vitriolisation*, to be also considered as an immanent instrument, so far as, in part, the air is not only inseparably contained therein, but is almost the very substance of fire itself; also seeing the fatty, phlogistic particles from wood or coals cannot fail to be communicated (hence an open-roasted resolves better to *vitriol* than a close desulphurated *pyrites*) yet here, fire and air are not to be considered on an equal footing, but fire is also to be considered as a penetrating, opening instrument; particularly as what fits and prepares the *pyrites* for the action of the air. For, not only the sort in general, which must undergo the torture of the fire, is to receive from the air the true matter of the *vitriol*, but also that which immediately upon burning resigns its *vitriol*, is afterwards to be committed to the air, in order to a fuller yield.

Now, all sorts of *pyrites*, whether spontaneously *vitriolising*, or prepared for *vitriolisation* by the action of the fire, will take a long time, nay, a course of years, before nature has thereby worked them dead, or exhausted them of their *vitriol*: but as in the *vitriol-huts* the waiting so long would not defray the charges, besides, that the *vitriol* produced would be apt to be washed away by rain and water, or soak into the earth, and there be lost, were we to wait till the *vitriolisation* was fully finished; it

is therefore usual, within the year and day, to boil out the *vitriol*, according to the plenty of *heap-work*, and in proportion to the demand for the commodity. And should any one, in order to promote the business of *vitriolisation*, take it in his head, that ore, the more it is stamped small and powdered, the more it would lie exposed to the action of its menstruum, from the axiom, that *the more sides a body thus exposes, the sooner it will be resolved*, he would find himself greatly mistaken; as thus, the ore would lie more close together, so as to exclude the action of the air. Yet it depends on practice and experience, to determine whether the often turning what was inside outward, may be of any advantage or no.

It remains to say something of the white *vitriol*, a matter greatly unknown, both in its origination and mixtion: it is white, and not barely so to the eye, as *vitriol* in general usually appears, when in a capillary or woolly state, and consequently fine and tender, or when minutely rubbed, or dried and crumbled by air and heat; but essentially, and in its mixtion, white, as plainly appears from its crystals, be they ever so large and thick. It is true, we have also a bluish sort, but this external blue cast may, by a proper crystallisation, be discharged. Though its origination be utterly unknown to us, yet I cannot omit mentioning what I myself have observed, *viz.* that the *pyrites* of Pretzschendorff, which is a yellow cubical sort, intermixed with somewhat of a mock-leady matter, and lodged in a black-grey shivery rock, has, after desulphuration, and a long exposure to the air, yielded an actual white *vitriol*, differing in nothing from the Rammelsberg sort, so far as I hitherto find (after purging such from its adhering copper-blue) either

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in colour, taste, or habitude in the fire. And all we learn from the accounts from the Rammelsberg is, that the ores there are also *pyrity* and mock-leady.

In the Pretzschendorff sort, it is certain, that besides the *pyrites*, there is also mock-lead, which holds some iron-earth, and a little sooty fly-powder, or arsenic, consequently no other contents than what are in *pyrites*, and therefore the business should seem to turn on the unmetallic earth, which constitutes the greatest part of mock-lead, besides what the external rock may contribute; which though also to be met with in other *pyrites*, yielding no white *vitriol*, yet we are to remember, that new productions, as *vitriols* are, depend not so much on the great variety of matters to make up their mixtion, as on the different proportions of a few, the places of generation, *&c.*

From the former prejudice generally arises great difficulties in acquiring a competent knowledge of nature, in imagining, first, *mixts* to have taken their rise from such matters as they are found to consist of; the absurdity of which appears from the history of alum, which consists indeed of a calcarious, or if you had rather, a chalky earth, and yet neither nature nor art can produce it from thence: again, in being accustomed, in the operations of nature, to the terms, *extraction*, *separation*, *combination*, &c.

As to the mixtion or nature of the white *vitriol*, so far as my little observation reaches, it may be concluded, its ground-earth is, first, aluminous, then, coppery; the copperiness not only appearing in the common white *vitriol*, as worked from the Rammelsberg ores, by plunging an iron into it,

but

but also in the purified, and even the Pretzschendorff sort, which discover themselves by the actual coppery taste, and by its redness after calcination; this colour certainly indicating something metalline, though, from the taste, not an iron.

It might be somewhat difficult to explain why such a white metal-salt should not be procured at our *vitriol-houses*, equally as at the Hartz, did not the business depend on the copperiness of the *pyrites*, which is observed to be more distinguishable there than with us: and as to its unmetallic earth, we have reason enough to affirm, it is not of the same sort with the ground-earth of bitter salts, and arises, if not from common salt, yet from calcarious, spathy stone, from which such middle or *vitriolated* salts indeed may, but a white *vitriol*, though with the addition of a metallic earth, never can be prepared; moreover, we observe nothing spathy among our Pretzschendorff veins: nay, such a *vitriolated* salt may well contain something metallic, as the *arcanum duplicatum*, which, in the burning or distilling for *aqua fortis*, arises from the alcaline salt-petre earth, and the *vitriolic acid*; yet so that its fundamental bitterness cannot be concealed, though entirely separable from the metallic impurity; whereas, on the contrary, there is, in the white *vitriol*, neither bitterness to be observed, nor does the metallic taste cease to manifest itself.

Lastly, we are to take notice, that white *vitriol* is never found in our grooves; though, according to Lohneiss, in those at the Rammelsberg, it is met with native in the form of icicles and roses. Thus much we know, that it is procured in the way of a crystallisation, not in large shoots indeed, but like

like a sand only, while urged by a brisk boiling; though from these smaller crystals reducible to larger lumps.

On the head of the origination of white *vitriol*, I cannot omit mentioning a query put to me by an ingenious friend, namely, Whether *zink*, or rather, zinky substances, should here be entirely disregarded? This at least is true, that this surprising body principally shews itself at the Rammelsberg, nay, is no stranger with us at Friberg, under another form indeed; though the greatest artist will find it difficult enough to hit on a method of properly combining it in its separated state with the sulphur-acid, into such a white *vitriol*.

Under the head of *vitriol* from *pyrites*, we must observe the difference of elixations, namely, that many of them, having stood for some weeks, turn mouldy, as happened to myself once from the *mixt-work* of the Rothe-grube; and again, if I mistake not, from the *terra martis Hassiaca*. Now *pyrites*, as such, exhibits no such appearance, but the adjoining interspersed minerals, and indeed the shivery, loamy, black fatty sort may, though not all, yet a certain sort of them; such in general are those that yield alum; and all of a fatty, bituminous, inflammable nature, or of a muddy origination: though I propose this only as a query, and not as a certain undoubted truth.

There is also incidentally, from the process of *vitriolisation*, alum procured; not from the *pyrites* in its proper mixtion, but from the bituminous matter adhering to the *pyrites*; when its acid chances to lay hold on the metal-earth, it may not, at the same time, leave untouched the black, fatty, adjoining

joining and interſperſed mineral, and thence exhibit alum. We purpoſely omit mentioning why ſuch vitriolic, aluminous *lies* now ſhoot firſt to alum, and that *per ſe*, without a precipitant, as happens in thoſe of Braunſdorff; again, why to *vitriol* firſt, and then to alum, not eaſily without a precipitant; and how alum, made *per ſe*, differs from that made with *addition*, as ſometimes of urine, then pot aſh, then quick-lime, and ſometimes of ſpirit of urine; and the rather, as we expect a particular diſſertation on the ſubject of alum from profeſſor Baier, at Altorff.

An earth here diſcovers itſelf, which is ſometimes grey, ſometimes yellow; the former called *ſlime*, the latter, *ochre:* the ſlime is procured not ſo much from *pyrites*, as from the earth intermixed and incorporated with it; though whether ſuch earth be ever procurable from the mixtion of the *pyrites* itſelf, a thing I could never find, deſerves examination; the ochre, on the contrary, appearing of a brown-yellowiſh, alſo of a ruſty caſt, and conſiſting partly of a metallic, ſometimes iron, ſometimes copper, and partly of an unmetallic earth, is more certainly derived from the *pyrites*, though not immediately, but mediately only, by means of the *vitriol*, to which the *pyrites* muſt be firſt reduced. It is found not only near and upon crumbled *mixt-work*, but waſhed away by the waters; in what is called the *gurs*, or metallic juices, and deſerves a peculiar regard; as does alſo that ſulphur-yellow earth, precipitated in boiling for *vitriol*, and burnt to a red colour, yet not to be confounded with the ochre, being not only brighter, but alſo ſomething more than a pure earth, namely, ſtill conſiderably *vitriolic* and aluminous.

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There ſtill remains to be conſidered a mellaginous liquor, deſerving the more notice, as it has been diſregarded, or, at leaſt, not expreſsly mentioned by any authors, except Geoffroy * and Stahl †. This liquor is ſuch, that (1.) though, by means of the gentleſt evaporation, ſome ſhoots may be ſeparated from it, yet they are not ſufficiently cryſtalline, and what remains will not ſhoot further, but only become a dried maſs. And (2.) which is the more immediate object of our preſent attention, that after drying, if again expoſed to the air, it becomes ſmeary, moiſt, and fluid. Again (3.) when dried ſpontaneouſly in a warm air, it ferments like lees, and thus its parts undergo a mutual action among themſelves. And here may be conſidered, what, and how many are thoſe juices, or thick liquors, which contain ſalts, without reſigning them, either to cryſtalliſation, or the other methods of ſeparation; but, for the preſent, I ſhall confine myſelf to the mineral kingdom.

We find arſenic, and what is allied to it, orpiment, *&c.* which, along with the acid of ſalt-petre-ſalt, turns to a very ſurpriſing viſcous matter: metals might generally be reduced to this form, could the proper medium for each be found out, as the abovementioned friend informs me from his own experience, of gold by means of urine. This buſineſs, however, ſucceeds with iron and copper eaſier than in any other metals, and in a peculiar manner; eſpecially as they are the two, that, along with the ſulphur-acid, aſſume the ſurpriſing beautiful form of *vitriol.*

Copper

* Mem. l'Acad. l'An. 1713. p. 225.
† Bedencken vom Sulphure, p. 285.

Copper furnishes a remarkable experiment to this purpose, upon properly evaporating the green water remaining from a solution of silver precipitated by copper; but iron more clearly, as I have found after employing the greatest degree of care, having more than once observed, that working it with oil of *vitriol* for *vitriol*, there ever remained something oleaginous, that could not be made to shoot, and only became a dried mass: and as I did not over, but rather under dose the iron therewith, I at first began to suspect the purity of my iron; and being well apprized that many sorts of iron, particularly the cast, though I never employed such in this process, nay, other common iron, may contain something extraneous, as common sulphur, which is no constituent part thereof, sometimes lodges therein, I employed the best Steyermarck steel, as pure an iron as is possibly procurable, and yet even this sort manifested the same thick oleaginous liquor that common iron did, and became dry in the fire, but smeary again in the air.

After the arsenical matters, and the metals, the *vitriolic*, and the like mixtures, are what are procured from *pyrites*, either with or without fire, also from calamy-stone, and the fossile Hungarian *vitriol*; as thus, take *vitriolated pyrites*-mixt-work, as of Braunsdorff, and the Rothe-grube; also *vitriolated* Hessian earth, burnt fossile calamy, Hungarian *vitriol*, without picking out the green pieces; taking the white amongst them as they come to hand, dissolve each in water, filtrate, boil, and evaporate, and set to shoot several times again; then commit what remains, which will prove highly oleaginous, to the softest degree of a spontaneous

neous evaporation, without applying any fire, and thus let it stand for some months, and there will something separate in that time, which proves not crystalline, but crumbly, like hemp-seeds and small pease, and what remains after, proves still thick and oleaginous, as before. Now nothing further happens, but that when the last is not removed with the same care, but the whole left long together to dry away in the mild warmth of a stove, this oleaginous mass, when become of the thickness of butter, heaves and rises like a dough, in its state of fermentation.

As to what M. Geoffroy * has observed in this case, though he divides *vitriol* with more accuracy than M. Lemery, into blue, green, and white, yet he appears not to have had so just a notion of the white sort, which he calls *couperose blanche* †, as he pretends it to be mixed either with some calamy (which it may, in regard to the earth it holds for the generation of alum, and possibly also for the basis of the white *vitriol*) or to consist of an irony earth, and some lead or tin, a prejudice he was probably led into from the white colour of the *vitriol*.

Now the oleaginous smeary matter remaining after the shooting of the *vitriol*, and which he calls the *mother-water*, he procured not only from fresh *vitriol*, but also from the sort he dried to whiteness, and likewise from what he had treated in the fire to yellowness, for obtaining the volatile spirit of *vitriol*. He then observes, that from fresh *vitriol*, upon the first re-solution and crystallisation, a grey muddy earth had settled to the bottom of the glass; a thing

* Hist. de l'Acad. l'An. 1707. p. 237.
† Ib. l'An. 1713, p. 48. & Mem. p. 225.

a thing I never remarked, though I have committed *vitriol-lies* to as long a degree of evaporation and ſeparation, as ever M. Geoffroy did.

It is true, I obſerved ſomething of a ſulphur-yellow, but never ſuch a grey muddy matter from pure *vitriol*; whence I conclude, his *vitriol* was impure, or otherwiſe ſullied. He again obſerved, that after ſtanding in the fire 'till gilded, it yielded a larger quantity of it, than if dried to whiteneſs only, and ſtill more, than if taken juſt freſh for the ſeparation of this *mother-lie*. Again, that this *vitriol*, once uſed, yields the ſame a ſecond, a third, and a fourth time, nay, repeatedly, or 'till the whole maſs of *vitriol* employed be thus conſumed and ſpent. Further, that upon each repetition he procured a yellow powder: that the *mother-lie* grows hot with the acid of *vitriol*, ferments remarkably with the acid of nitre, with oil of white tartar, at firſt only ſoftly, but ſoon after alſo in a violent degree: that after drying and ignition in a briſk fire, it again turns ſmeary and fluid in the air.

Now, in order to account for this, M. Geoffroy affirms firſt, that it muſt be allowed to be, in ſome degree, alcaline, as it appears ropy, like a run lixivious ſalt, and violently effervеſces and heats with the acid of nitre, like any other alcali: alſo, that this ſalt is only derived from the acid of *vitriol:* and then, that being not only in taſte, though without any remarkable acidity and ſharpneſs, aſtringent, but likewiſe fermenting and heating with alcali's, there may be a proper vitriolic matter ſtill contained therein, ſeparable by accurate repeated ſhootings; or if ſtill withheld, may, in time, ſpontaneouſly bewray itſelf in the yeſt thrown up

up in the courſe of the fermentation: and laſtly, in regard to the cauſality of this alcaline *vitriol*-liquor, he explains himſelf in ſuch a manner, as would make one imagine a tranſmutation of the *vitriol-acid*; but he does not ſay, at leaſt not diſtinctly enough, whence the matter is derived, which we muſt doubtleſs ſuppoſe, for the exhibition of a dry lixivious, and the incorporation of the acid ſalt.

That the acid ſalt of *vitriol* ſhould become, I will not ſay alcaliſed, yet changed ſo as to loſe its nature and eſſence, appears, among other inſtances, from diſtilling oil of *vitriol* upon quicklime, when there ariſes a maſs that entirely turns moiſt in the air: but even hence we ſee there is ſomething which deſtroys not only the mixtion of the acid *vitriol-ſalt*, but muſt alſo give it a body. In ſhort, this change cannot happen without ſome concurring cauſe, and what is here procured cannot properly be held for a changed *vitriol-ſalt*, but for a third thing, ſomething which muſt take its riſe from the two other, namely, the acid ſalt, and an earth.

To give my own thoughts upon this ſubject, we are to obſerve, firſt, that ſuch ſoluble, vitriolic remainder ſhews itſelf on three different occaſions; (1.) upon the lixiviation and elaboration of the *vitriol* from its crude ore; (2.) upon the re-ſolution and cryſtalliſation of a purified *vitriol*, already ſeparated from its ore; (3.) in the uſual way of preparing *vitriol* with iron and oil of *vitriol*.

The ſecond is what gave occaſion to M. Geoffroy's remarks, but which I muſt paſs over. The firſt, of which he makes no mention, is properly within my province, as relating to the *vitrioliſation*, conſequently the hiſtory of the *pyrites*. The third

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I have only employed as a kind of auxiliary means towards the discovery of the cause of this surprising vitriolic production.

And here, to abide by the first, I have found, (1.) That all crude *vitriol-boilings* leave behind a fatty, thick, oleaginous lie, be the *pyrites* prepared either with or without fire, *vitriolised* above or under ground, and the vitriol soaked in the earth and stone, or caked together in the open air.

(2.) It ferments with alcali salts, and lets fall a bright brown earth, but never with acids.

(3.) Upon setting it by for some months out of the reach of the fire, something shoots from it like small crumbly grains, plumose and aluminous, as was already observed.

(4.) But, if the whole be left together to evaporate, without separating this matter, it turns thick like a resin, and at last becomes a grey whitish mass.

(5.) In the course of the evaporation, which is performed in the soft heat of a stove, I once observed it heave and rise, and the glass, scarce a third full, to become quite filled therewith.

(6.) This grey mass taken directly, whilst hardly cold, ferments readily with alcali, but in no sort with acid.

(7.) Even upon exposure in the air, it turns moist and smeary, exhibiting the same phænomena with acid and alcali as before.

(8.) Di-

(8.) Diſtilled in an open fire, it yields an acid ſpirit, and leaves behind a bright, brown-red earth.

(9.) This earth ſtill proves moiſt in the air, yet more or leſs, according as it is more or leſs burnt.

(10.) Even after ignition in a crucible, it ſtill attracts, though in a very ſmall proportion, the moiſture of the air.

(11.) The laſt ſeparated aluminous matter, n° 3. diſtilled apart, gives alſo an acid water, and leaves behind a ſpongy, grey, and here and there reddiſh ſpotted cake, which equally turns moiſt and ſmeary in the air, as n° 7.

(12.) What remains behind of n° 3. proves neither thicker, nor more oleaginous than before.

(13.) What remains from the *vitriol*, prepared from iron and oil of *vitriol*, and dried, turns alſo ſmeary, flows in the air, and ferments with alcali, but by no means with acid.

Now, from theſe proofs thus much at leaſt appears; that this oleaginous reſidue, from *vitriol*, does, after exſiccation and ignition, become ſmeary, nay, ſometimes flows in the air; but whether it will ferment with acids, and thus exhibit an alcaline nature, is a different queſtion; not that I would entertain any doubt about M. Geoffroy's experiment, as being made and repeated expreſsly, and not a thing purely incidental, though it is what I could never obſerve: but that it may be exceedingly poſſible, appears, as was above ſaid, from its ſponta-

neous fuming and frothing, and turning, after exsiccation, smeary in the air, like an alcali.

Whatever be in that, thus much we know, that this *vitriolic* residue consists of two parts, namely, the *vitriol-acid*, and an earth, as appears by an entire expulsion of the acid, by means of a thorough glow; whence it seems that these two parts were but slightly combined, consequently, that they cannot constitute a genuine alcali, as from such the *vitriol-acid* can never be expelled *per se:* but again, there must also be an earth; without which no exsiccation can be procured; and he who considers, or rather, manually treats salts, with respect to their productions, transmutations, origination from, and reduction to earth again, will find such phænomena exhibited from a *vitriol-acid*, and an earth; though he may be unable to assign the formality, or remote causes, which generally lie concealed from us in other instances.

That this earth is from iron seems probable; for to what Homberg † has remarked of an iron fattiness exhibited by means of a burning-glass, and what others credibly relate, of a quicksilver from iron, Dr. Rothe has added some weight, in his dissertation on metallic salts: not that I would ascribe any thing peculiar to iron before other metals, as it is a sort having only proximately its origin from a crude unmetallic earth, and with which, as one of the coarsest, earthy metals, many things may chance to be incorporated.

A brown-red earth, called *caput mortuum*, remains behind from *vitriol-lies*; but then only to be so denominated, when no longer containing any thing living and pungent, *i. e.* saline and sapid; con-

† Mem. l'an. 1710, p. 303.

consequently, is a thing dead and effete, no more to be boiled for *vitriol*, but thrown away as useless.

Two queries still remain behind, *viz.* (1.) Whether a *vitriol* may not also be arsenical, or partake of arsenic: The reason of the query is, that *pyritæ* are not without arsenic.

(2.) How the case holds with the *vitriol* and its *pyrites*, also with the alcaline earth in medicinal springs.

A certain spring, which I highly esteem, but leave nameless, to prevent the entertaining any prejudice against, or disadvantageous opinion about it, gives occasion to my first query. That it is arsenical is plain, not only from the white sublimate procured from it, but also from the actual arsenical odour, it strikes the nose withal. Yet, neither on this nor the other circumstance, is any great stress to be laid at all times, especially when the arsenic is in so very small a quantity, as is the case here, that it cannot be sufficiently examined; for, phosphorus also gives forth an arsenical odour, which I have also smelled from a lead-process, where nothing arsenical, but salts only were employed; and salts, such as are in the nameless water, may, in their mixed crude state, volatilise a little, though not, in their separated state, or not so easily without peculiar *additions*, appropriations, *&c.*

As *pyrites* generally contains arsenic, this arsenic may lodge in that sort from which the water may receive its mineral constituent portion. The possibility of the thing appears from the Friberg

schlacken-bad, where some arsenic, by means of sulphur and *vitriol*, insinuates itself into the water, which notwithstanding, has as good effects, and performs as good cures as any other medicinal water. Not that we are to imagine such waters to hold great quantities of arsenic; it sometimes scarce amounting to grains, nay, not to one eighth of a grain in several pounds of water, as I have found in the *schlacken-bad*.

And though a water should happen to hold a greater quantity, if not to a very extraordinary degree, it should not therefore be considered as noxious and poisonous, but its innocence, nay, usefulness, ought to be judged of by the effects, and not by pre-conceived speculations. It is, however, true, that of all the *vitriols* I have ever examined, I found no one sort arsenical, though such a thing might be surmised from some *groove-vitriols*, in consideration of the arsenical admixture in their *pyrites*.

Lastly, to mention something on the head of *acidulæ* and *thermæ*: these certainly, in regard to their *vitriol*, sulphur, iron, copper, arsenic, also their alum, take their rise only from *pyrites*; the *vitriolisation* of which loosens these parts, and fits them to incorporate with the intercurrent waters, and to render them mineral.

The other contents, either a pure, or a *vitriolated* lixivious salt, though the last becomes such by evaporation only, are by no means produced, as none such can be procured from *pyrites*. And here principally we have two queries to make.

(1.) How

(1.) How it happens that moſt of theſe waters contain the above-mentioned minerals in a very ſmall quantity.

(2.) How two ſuch oppoſite matters, as a lixivious ſalt and a *vitriol* can conſiſt together, without laying hold on each other.

As to the firſt, we have often water in the grooves, remarkably *vitriolic*; but, ſo far as my knowledge of the ſprings in Germany, England, France, Hungary, *&c.* reaches, no ſuch thing can be affirmed of thoſe at the day, ſeeing theſe diſcover only the leaſt *vitriol*, or other mineral poſſible: which, in ſome meaſure, we may account for from ſuch waters taking their riſe nearer the day, when the more day-water coming to mix with them, they thus become weakened and diluted.

But then, that mineral ſprings ſhould remain of one conſtant yield, and become neither richer in hot, dry, ſummer-weather, nor remarkably ſmaller or poorer in the moiſteſt harveſts and ſprings, we muſt aſcribe to ſuch waters having a diſtant, deep, and not a near origin, not only in reſpect of their mineral particles, but alſo their univerſal watrineſs; likewiſe, to ſuch *pyritæ* as *vitrioliſe* ſparingly and leiſurely: not to inſiſt on their great plenty; as there are ſprings that have continued running for a long courſe of years; which ſhews the ſtock they are derived from to be inexhauſtible.

Hence we exclude all *pyritæ*, vitrioliſing ſo eaſily, ſo richly and ſo quickly, as the round in ge-

neral do, which lie directly under the surface of the earth, as those of Altsattel, Almerode, *&c.* For the same reason also we deny the *copper-pyrites*, or copper-ores, as these always supply a *vitriol*, if not entirely, yet in part coppery; consequently, a something not to be met with in our medicinal waters.

We must therefore have recourse to *pyrites*, *breaking* in fissures and veins, and not coppery; and affecting, if not the cubical, yet the angular figure; which are not, or least of all, coppery, yet vitriolsing difficultly and sparingly.

As to the other query; namely, how such opposite matters, without being thrown up together, and thus continuing in their mixtion and nature, can remain separate and undestroyed. This is not the only instance we have in nature, being furnished with a similar one in the above *vitriolic* residue, wherein an alcaline and acid salt lie contiguous, and remain at rest, though at length they are embodied, and discover themselves by a fermentation or heaving: nor again, are we at a loss to account for it; for the highest mineral acid never remains in a separated state, but always united to something; as here in medicinal waters, either to an alcaline or metallic earth. Now, when such waters come to ferment and heave with acid salts, we must certainly conclude, the alcali therein is neither combined with, nor subdued by the acid; and though, by means of evaporation, a yellow earth falls down, such must arise from the destruction of the *vitriol*; and from the falling down of the earth, we may conclude to the presence of the acid, as being separated from this earth, and only unobservedly insinuated into the adjacent alcali;

alcali; and the more ſo, the more it is ſet free from its vitriol-mixtion by continuing the evaporation.

That theſe do no ſooner lay hold of each other, muſt be owing not only to their diſperſion, but alſo to the over-proportion of water. For, as ſoon as only a little of the water is evaporated, ſo ſoon do theſe antagoniſts fall upon each other, after having hitherto remained ſo long in peace. Now, as the acid ſooner, and more firmly unites with alcali than with metallic earths; ſo here the acid lets go the metal under the form of a yellow earth, and combines with the alcali.

Here I mean only ſuch waters, where, along with the *vitriol*, the alcali manifeſtly lodges, as is generally the caſe in medicinal ſprings: but ſhould you meet with *vitriolic* waters, affording no ſuſpicion of an alcali, nor exhibiting any; and yet the *vitriol*, after a degree of evaporation, coming to be deſtroyed, as ſhall ſufficiently appear by the precipitating yellow earth, there muſt be other reaſons of this appearance, or your experiment has not been accurately gone about.

If no formal alcali can be exhibited, it muſt then be common ſalt that preſents its alcali; whereby *vitriolic* waters turn eaſily muddy and ochry; again, if no common ſalt, it muſt be ſomething earthy, without participating of which a ground-water ſeldom is found, to which, if the *vitriol-acid* does not faſten, yet it may become contiguous, ſo as to let fall its metallic earth, which does not hold very firm thereto: and if there is no precipitation, yet waters generally, by long boiling, leave behind an unctuous, fatty, browniſh liquor,

taſting

tasting bitterish, smelling lixivious, and though not formally alcaline, nor yet visibly fermenting with acids, but approaching thereto: this appears at least from all our Up-land, and probably too, holds good of the Low-land waters, provided other gross, earthy, and saline parts intermixed, stand not in the way of a proper separation and exhibition. Moreover, there is no great difficulty to resolve a body of such feeble texture as *vitriol* is (which gives in the very air) especially that little of it generally in waters.

Further, concerning the alcaline salts in mineral waters, though it be difficult to assign their origin, yet there are several springs, from which they may be procured in a quite easy manner. For, not to mention common salt, as being plentifully to be met with in the earth, and which (a thing well to be observed) is the only matter, from which, with the addition of the acid of sulphur or *vitriol*, a bittter salt, like that from *acidulæ*, is procurable by art; especially as such bitter, or spring salt is to be met with in all *soles* or brines, as Professor Lehman, a person much conversant in salts, has discovered: nor to insist on lime-stone and gypsum-stone, nor what is allied thereto, spath, nor cat-silver, Muscovy-glass, *selenites*, *glimmer*, and the like, as being all of a spathy, and spath of a calcarious nature, and all, in particular spath, which lies by *pyrites*, of an alcaline nature, and with acid capable of putting on the appearance of a salt, as we learn from the white *tophus* in the Prudel spring at the Carlsbad; I shall only propose, by way of query, another sort of earth or stone, which the alcali in question may, among other things, be ascribed to, especially when we come to consider the business of the conversion of earths into salts, and

and of ſalts into earths, and of theſe laſt among themſelves; namely, that fatty, black, grey, ſhivery, unctuous earth and ſtone, eminently *breaking*, by *pyrites*, and from which alum is uſually produced, and thus probably of a luty, ſlimy original.

Amidſt certain circumſtances, eſpecially as ſoon as ſuch earth, procured from ſuch ſtone, is laid hold on by the vitriol-acid; or rather, as ſoon as the acid in this ſtone itſelf comes to work; or more properly ſtill, as ſoon as this ſtone comes to act upon itſelf (whereby not only the vitriol-acid by the attraction of the air, but alſo the aluminous earth is formally made; in ſhort, the alum produced not only in its whole, but its parts) there indeed ſuch ſtone cannot arrive to the alcaline earth we are here in queſt of, as in this production in general, not proving ſaline, but ſtubborn, calcarious, or highly cretaceous. And yet, what is this more than a converſion? But, when the vitriol-acid comes not thus in play, as we may learn from the alcali lying quite naked and unſaturated in *acidulæ*, and thence coming to ferment with acids, there indeed the circumſtances, conſequently the difference cannot minutely be made out, but muſt be charged to the ſcore of the difference of elaboration, and other incidental circumſtances: ſo alſo ſuch ſtone exhibits not its habitude to acid, but ſomething, namely, the alcali, according to aptitude rather peculiar than incidental to it. In ſhort, let this ſtone be properly burnt, and the alcali, tho' in a very ſmall quantity, will become manifeſt not only from its habitude to acid, but alſo from the actual exhibition of a bitter ſalt.

But

But here it will be objected (1.) that such waters also hold an acid, and thus the alcali lies not naked therein; (2.) that we must here mean not an alcali prepared by fire, but a natural sort; (3.) that even in this formation of alum, an acid and alcali come together, as when one conveys an acid on such burnt stone, and yet *there* no bitter salt, *here* no alum is produced. As to the first, it is true, the alcali is not combined with, but stands apart from the acid, which is still joined with the metallic earth, as was said. As to the second, the axiom holds good, that we cannot form any just conclusions from what happens above the earth, or by means of art, to what happens spontaneously in the bowels of the earth: nor, conversely, that what happens not above the earth, or by art, may not happen naturally under the earth, in certain circumstances, through length of time. Again, here serves the experience or observation of a calcarious earth, or stone, being not only corroded by, but capable of being incorporated with bare water, which shall still remain clear and transparent: and as to the third, in the instance objected, the acid is not first produced or formed, but derived, as already formed, from elsewhere; whereas, in the other case, it must become such in the act of *aluminisation*, so far, namely, as it arises, without *pyrites*, from the pure stone abovementioned.

CHAP.

CHAP. XIII.

Containing the ſeveral USES of the PYRITES; and, 1. with reſpect to the making of SULPHUR.

PYRITES is worked for ſulphur, either expreſly or incidentally; in the one caſe it is *driven*, or forced off in pipes or retorts, in the other procured in the courſe of roaſting the ores: by the former method, both here, at Friberg, and at other places; by the latter, particularly at the Hartz, as follows, according to Lohneiſs *.

'They take, ſays he, of the ſmall ore, that is, 'both of the ſmall ſweep from the ore of the 'grooves, and from the vitriol works or lies, call-'ed alſo *vitriol-ſmall* and *kernel* †, and ſhoot it on 'a heap one foot high by twenty broad and long; 'on this there is wood laid cloſe together, the 'whole breadth of the ſmall ore, and piled three 'foot high; then on this wood the ore is *ſhot* in 'greater or ſmaller pieces, as it comes to hand; 'and, to one roaſt, are taken between 1500 and '1600 meaſures, each weighing 5 and 1 half cent-'ners: the roaſts are made ſquare, and raiſed nine 'foot high, and covered all over with moiſtened 'ſmall-ore for a large *band thick*, and ſtruck cloſe 'and firm. From the middle of the roaſt is 'reared a brand of dry wood, reaching quite thro' 'the ore, and over-topping the roaſt. The roaſt 'being

* Bericht vom Bergwerk, p. 80.

† Kernel is the beſt or richeſt ſmall ore.

'being compleated, the ſmelters take from the 'huts a ladle-full of hot ſlags, pour them in on the 'brand, ſet upright in the roaſt: and the wood 'generally burning down in a night's time, the 'ore, if left to itſelf, will continue burning for 'eight, nine, or ten weeks. There is much *ſul-'phur* procured at preſent from the Rammelsberg 'ores, of which the old workers knew little or no-'thing, and much more may ſtill be obtained, by 'proper management.

'For inſtance, thus the covers of the roaſts be-'ing, as is ſaid, burnt down, they become ſoft 'by the great degree of heat; and then, with a 'piece of timber, they are ſtuck full of round 'holes, for the *ſulphur*, which retires into them, 'to be laded out with iron ladles. The *vitriol-'ſmall* and *kernel* here employed, ſhould ſeem to 'promote the caking of the covers, to prevent 'the more eaſy evaporation of the ſulphur.'

Inſtead of the above holes, they now make certain ſinkings, or pits, about two feet in diameter, by a foot and a half deep, which are ſtruck firm with *vitriol-ſmall*, and ſtand aſunder the length of one diameter. Now, the roaſt burning from below upwards, the *ſulphur* retires into theſe pits, out of which it is laded with iron ladles into moiſtened tubs. It would require no fining, did not ſome of the *vitriol-ſmall* drop into it in the lading, and thus taint the *ſulphur*. The firſt fining is performed in iron coppers, wherein the *ſulphur* melts; and after the coarſe, impure parts are ſunk to the bottom, it is caſt in moulds; what thus remains behind, is in the ſecond fining treated like the crude *ſulphur*.

The

The method of *working sulphur* expressly at Friberg, M. Rosler * describes thus: 'For the purpose, there must be a driving and a fining furnace, both to be properly proportioned. The sulphur, or driving furnace, is built in length, in such a manner, as between the two front, or head walls, to admit of either eleven, thirteen, or fifteen pipes, to reach across from wall to wall; also lower, there are either six, seven, or eight pipes, placed at a height; over the spaces between these, another row of five, six, or seven pipes, also at a height, so that each pipe may come to be within the reach of the fire, and become ignited. The width of this furnace must be determined by the length of the pipes. Over the pipes, from one head or front wall to the other, is turned or cast a flat arch of tiles, with a number of holes left, of the size of a small arm, for discharging the smoke of the wood. The pipes are made of good stuff or clay, and two and a half inches thick, and nine inches wide at the mouth, which is flat in the under, and somewhat round in the upper part, and to be so made, that a clay plate may be shoved down over it, and again removed occasionally; from the mouth they run tapering off to the other end, where the *sulphur* runs out, leaving an aperture only of an inch. Behind, where the *sulphur* runs out, there is left on the wall a settle, whereon the lead-pans may stand to receive the snouts of the lower pipes; and for each upper pipe a small wall is raised for their pans. The pans are square, with a flat half cover, reaching half way: some cold water is put into the pans, for the *sulphur* to run into and be quenched in. The furnace is heated with billet-wood laid on a grate, through which the coals may fall down. You must be well ac-

'quainted

* Berg bauspiegel. l. iv. cap. 16. p. 155.

'quainted with the nature of your *pyrites*, as all 'of them cannot equally with profit be worked for '*ſulphur*; alſo know, what quantity may be lodg-'ed in at once and burnt in eight hours. When 'eleven pipes are employed, for the week about '126 centners of *pyrites* muſt be worked, eighteen 'centners for the twenty-four hours, and ſix cent-'ners worked each time for eight hours. From '*pyrites* of an ordinary *yield*, there may in a week 'about five and a half centners of fined *ſulphur* be 'procured, the centner of *pyrites* reckoned at four 'and 1 half pounds. The pipes, as was ſaid, muſt 'be made of good ſtuff, and not overcharged, as 'the *pyrites* is apt to ſwell and heave, which 'might endanger the pipes. Alſo the arch, next 'over the upper pipes, to be left open, there be-'ing then a greater degree of heat, and a better 'drift of *ſulphur* procured.

'The crude *ſulphur*, when there is a quantity of 'it together, is done out of the lead pans into ob-'long fining pots of iron, which are lodged in the 'fining-furnace, and fitted with clay-helms and 'earthen receivers; and thus the *ſulphur driven* 'or forced off, and then from the receivers tapped 'off into other pots, wherein it is ſuffered to cool 'a little; after which it is caſt in moulds, in long 'rolls, and packed up in veſſels: in the fining 'there is a fifth part waſte. In the fining-pots, af-'ter forcing off the *ſulphur*, there remains behind 'the droſs, called *ſulphur-ſlags*; which, whilſt ſtill 'hot, are to be removed with an iron ladle. The '*pyrites* thus worked is thrown aſide, and ſome of 'it uſed as *additions* in the operation of *crude-ſmelting*, and the reſt of it boiled for vitriol; but 'what is deſigned for this laſt, muſt lie for thir-'teen weeks in the open air before it can be uſed.'

The method of *working for sulphur* at Dylta in the Province of Nericia in Sweden, we shall next describe. This is is one of the greatest works for *sulphur* in the whole kingdom; and here they also boil for vitriol and alum. The matters, from which all these things are drawn and prepared, are a yellow-greenish, dark-shining, ponderous *pyrites*, not *breaking* there in the high-land, nor at great depths, but beneath the under-turf earth in low-lands or levels, also in the firm rock or stone; and lies in layers or *strata*, that is like a *flat-work*, at between three and four fathom under a cover of common stone, about a finger thick. When they would work upon it, they clear away all to the ore, on which they lay wood to burn, and on the heated ore pour cold water, which makes it the easier to work; after which they break it in pieces, and convey it on a heap together: and as all this is done in the open air, they can only work at it in the spring and summer seasons; for, in winter and autumn, the groove, which is very wide, and stands uncovered, is generally half full of snow and rain. In the working seasons, twenty large iron pots or retorts, weighing between eighteen and twenty-one centners, are filled only a third, as the *pyrites* greatly heaves by the heat; and these pots are placed in a vaulted furnace, in manner that the bottom of the one shall touch on the neck of the other; and, on both sides of the furnace, are ten apertures, five in the upper, and as many in the under row. Then the iron-receivers are fitted on to the pots, and well secured with luting; and fire being made under the pots, the coarse *sulphur* is forced off into the iron-receivers at the rate of four and a half centners in twenty-four hours, according as the *pyrites* happens to be richer or poorer in *sulphur*; whilst some of

the fineſt parts, exuding through tne pores of the iron, and coagulated by the cold air, yields pure *drop-ſulphur*. Whence, in ſummer-weather, every morning about ſun-riſing, in harveſt and winter every evening, the *ſulphur* is removed out of the receivers, and the deſulphurated *pyrites* out of the pots, and replaced with freſh as before. The *ſulphur* is again melted in an immured pot over a gentle fire, in order to its fining, and then caſt in the uſual moulds. The deſulphurated *pyrites* is laid on heaps in the open air, and the following year, according as it happens to be moiſtened by rain, begins to take fire, and burn ſo long, till all the *ſulphur*, ſtill remaining therein, be quite conſumed. Thus far the more antient workers went; but the new, diſcovering that the deſulphurated heap was impregnated with vitriol, and the more ſo, the longer it lay expoſed, conveyed this refuſe into large veſſels, poured water thereon, and made a lie. But at preſent, it is put into lead-pans, and boiled for ſome hours with water: from the former, this lie is conveyed into other lead-pans therein to boil, till the vitriol-maſter ſees it is fit to ſhoot, who muſt have the dexterity of attempering it by pouring in ſome of the firſt lie. Now, after the lie is boiled, or ſoaked to a proper degree of thickneſs, the fire is lowered, and the lie poured into coolers, there to ſtand, till the vitriol ſhoots to cryſtals on the birchen twigs put therein. What remains unſhot, is again boiled along with new deſulphurated and vitriolated *pyrites* in the ſecond pans, and further brought to cryſtalliſation. The number of huts is two, of pans to each hut four; always two for crude lie, and two for good lie; each weighing thirty centners, and ſtanding on large iron grates, that they may come by no damage: and yet the pans for the good lie laſt not above five or ſix years, and thoſe for

for the crude, not above three; in regard the earth burnt-to adheres so firm to the lead, that, if never scraped off, the lead must needs melt. Now this lie, after all the vitriol is shot and removed, the alum-boiler takes to his hut, pumps a water thereon holding metallic particles, and adds a lie of wood-ashes, whereby the green vitriolic colour is discharged, and the white colour of alum procured; it is boiled over again for twenty-four hours in lead-pans, and afterwards suffered to cool and shoot; then the alum is fined and done: the remaining lie is put into a large vessel, and after standing for eight days, it concretes as a crystal into the figure of the vessels, and afterwards is broke in pieces, and is saleable, or fit for the market. There pass at least between five and six weeks, before a vessel which holds about eighteen centners, can be filled with alum; and when boiled in harvest or wet weather, or left too long in the vessel, it generally turns of a somewhat greenish cast *.

II. To the boiling for VITRIOL.

At the sulphur-works there is generally a *vitriol-work* too, as the burnt *pyrites* is well fitted for that purpose; though there is also a *vitriol* boiled from a *pyrites*, from which never any sulphur was made. Such a work requires a lead-pan seven feet long, six feet wide, and about two feet deep, weighing between twenty-four and twenty-six centners; then three lie-trunks, eleven feet square, and two feet high. From the burnt *sulphur-pyrites*, which give or resolve in twelve weeks time, there are ninety-six centners run into one trunk, and there lixiviated with water, and the lixiviated water collected in one

 vessel,

* Leopoldi relatio historica de itinere suo suecico. An. 1707. ad Dr. *Woodwardum*, p. 84. seq.

vessel, there to fine: then this lie is poured into the lead-pans, and boiled, and fresh lie always gradually poured in, that the pan may still remain full; according as the lie is strong or small, more or less *vitriol* is procured; generally, a pan amounts to between six and seven centners. In the boiling, care is to be had, that no sort of tallow, oil, butter, or grease, come nigh it, otherwise the *sod* or boiling is marred; and when it begins to have a skin, it is enough, and then the *sod* is let out into a large trough, wherein it may also fine; from this it is shared out into shooting-troughs, one of which generally yields one half centner of *vitriol*. In the shooting-troughs pieces of wood are suspended, whereon the *vitriol* may hang and shoot; the remaining *sod*, from which the *vitriol* is shot, is poured again into the pan to a fresh lie. At times, fresh roasts must be used for it, and that every week, for the lixiviated *pyrites* to be again burnt, and again lixiviated; they are so often used, 'till at last they must be sifted, to separate the small parts, which are of no more service, and though fluxile in smelting, yet give no *stone* or regulus. Sometimes the *vitriol* refuses to shoot duly, and here the masters use a peculiar piece of skill, which they will not readily disclose. In other places, where no sulphur is made, they use new and old *pyrites*, of which they make seven roasts, each at forty six centners; employ four large lie-trunks, and procure from the seven roasts in a week about forty centners of *vitriol*, for which there must be every week employed above one hundred centners of new *pyrites* *.

III. To

* Rosler's Berg bau-spiegel, Lib. VI. c. 17. p. 156. seq. Lokneiss, p 329.

III. To the making of ARSENIC.

Arſenic is made partly from a peculiar *pyrites*, or cobald, partly from a ſort, amongſt which tinſtone is found, partly from the ſmalt-cobald, partly alſo from the gold and ſilver holding *miſſpickel*, or white *pyrites*; and all theſe cobalds or *pyrites* muſt previouſly be parted from the barren minerals, by ſtamping and waſhing, and made into a pure *ſludge*, from which afterwards, by means of roaſting and burning, the *arſenic* is forced out in the fume, and catched. Formerly, the furnace had one ſmall aperture, by which the fire was kept up, and the *ſludge* ſtirred; was internally about eight feet wide, and ſomething longer, and two feet high, like an oven, with an arch over it, and on that a long horizontal paſſage, or funnel, of maſonry, eighty-eight feet long, of the height of a man, and three feet wide, called the *meal-funnel*; on the end of it was erected a pipe for diſcharging the ſmoke of the wood and the *arſenic* fume; at proper diſtances in the funnel were windows or apertures a foot ſquare, which were ſet open at taking out the *meal*. Now, when a *roaſt-work*, or quantity of *ſludge*, was burnt in the furnace, after being firſt well ſtirred, the *arſenic* or fume being retired into the horizontal funnel, fell, at length, like a meal, to the bottom, and, in part, adhered thereto. Upon the furnace's cooling a little, the *ſludge* was drawn, and replaced with other, which was roaſted and burnt ſo long and ſo much, 'till all its wildneſs was forced out, as was done to the firſt: and thus they proceeded, 'till they were to remove the meal from the long funnel, which was done by perſons whoſe faces were bound up, eſpecially the noſe and mouth, and who had before ſwallowed ſome bacon: but at

present they use a furnace, with a cavity and two mouths, and divided in two parts; and having over the smoke-vent such another passage or funnel, as above described, though not all of masonry, but partly of wood, nor quite straight, but with three or four crooks or windings, against which the arsenic-fume may strike, and the meal settle. The meal, in order to be fitted for market, must be sublimed like a cinnabar, which is performed in a hut, somewhat high and open above, like a roast-house, wherein is built an oblong, vaulted furnace, about three feet high from the earth, and so long, that three plate-hoods, the width of each asunder, may stand thereon. Above, in the vault of the furnace, three round holes are left with each a dish of cast-iron, and on each dish an iron hood of plate, below so large and round as to fit the dishes, and tapering to an aperture of the size of a man's arm. After securing the above hoods on the dishes, a quantity of the *arsenic*-meal is shot through the aperture into the dish, fire made in the furnace, and the meal directly sublimes into the hoods, being often stirred in the dish, by passing a stick through the aperture; and when a quantity has sublimed, they convey in more meal, 'till the hoods become sufficiently charged, and generally they let the fire in the furnace go out every evening, the aperture always remaining open: but the operators must bind up mouth and nose in charging and stirring the meal. Now, in order to procure yellow *arsenic*, amongst three centners of meal, between two and four pounds of sulphur are added, which being sublimed together, a beautiful yellow *arsenic* is procured *. Thus far M. Rosler.

IV. To

* Id. ib. Lib. IV. c. 18. p. 157. seq.

IV. To the operation of CRUDE-SMELTING.

The operation of ſmelting ores is the ſeparation of the metals, firſt, from the parts, reducing metals to ores, namely, the ſulphur, arſenic, and the unmetallic earth, intimately lodged in the ore-mixtion; and beſides, from unmetallic, ſtoney, earthy matters, externally adhering thereto, and incapable of being waſhed therefrom. With us at Friberg, this operation is principally two-fold, namely, (1.) the *crude-working*; (2.) the lead-working, from which afterwards flows the copper-working. The *crude-working* is that wherein the ores in their crude ſtate, that is, not only with the adhering unſeparated mineral matters, but alſo in their unroaſted ſtate, are lodged in the furnace, and ſmelted with ſerviceable, fluxile ſlags, and the beſt or pureſt part of them brought to ſome degree of concentration, or to a regulus, called *crude-ſtone*. The lead-working, to which the above crude-ſtone is taken, after a previous roaſting for three or four times, and the ore, employed therein, and which is moſtly *glitter* or lead-ore, and rich ſilver-ore, is not only well cleaned, by picking, ſtamping, and waſhing, but has alſo undergone a number of roaſt-fires, and is well ſeparated from the ſulphur and arſenic. My only reaſon for comparing both theſe operations together is, that in the firſt, the ores are unſtamped, unwaſhed, and unroaſted, but in the ſecond, well parted and roaſted, without making any diſtinct head of our copper-working, as it coincides with, and alſo flows from the lead-working; where, namely, the *lead-ſtone*, that is, the crude copper cake, or regulus, ſettling down from the former, alſo after repeated burnings or roaſtings, when it comes to be denominated *copper-ſtone*, is

first ſmelted, and brought to black-copper, and this, at length, after ſeparating or draining the ſilver, made pure or fine. Here I have only to make mention of the crude-working or ſmelting, as *pyrites* is uſed therein, and is, not only in this caſe, the principal agent, but alſo, in regard to its other uſes, for ſulphur, vitriol, and arſenic, here the moſt important thing.

Now the ores, when landed at the *day*, are firſt picked and ſorted; what is quite clean and pure, as lead-glitter, black-lead; or very noble, as red-goldiſh or white goldiſh (though theſe are not always quite pure) is roaſted, and thus directly taken to the lead-working; what is quite barren, rocky, and unyieldy, is thrown away. Not only in this picking, but alſo in veins, there is procured much of a middle degree of goodneſs, holding neither much in noble nor ignoble metal, but yet not to be entirely thrown away; for inſtance, firſt, highly rocky or ſtoney mixt-work, as quartz, ſpath, *kneiſs*, horn-ſtone, cat-ſilver, Muſcovy-glaſs, glimmer, and lime-ſtone; then alſo, in general, with us at Friberg, mock-leady matters, wherein, notwithſtanding ſomething of a good ore, in particular glitter, copper-ore, and even nobler matters, either in eyes, or interſperſedly, or in the moſt tender fibres, and which can in no wiſe be ſeparated with profit. For, to employ ſtamping and waſhing thereon, would not quit the trouble, or the metal would be waſted and loſt, eſpecially in the caſe of tender interſperſed noble ſpangles; and equally unfit would ſuch prove for roaſting, as by that means the rocky matters, which here cauſe the only inconvenience, would not thus be removed or corrected. Now, in order to work ſuch ores, the method of *crude-working* was deviſed, and is, hitherto,

therto, found the best means for that purpose; and therein the *pyrites* is the principal instrument, as by its means the heap-work, wherein the metal lies widely dispersed, is, by procuring the *crude-stone*, concentrated or brought within a narrow compass, and afterwards this stone duly worked by roasting and smelting, for procuring the metal-yield; and after repeated roastings gives forth its silver by means of the lead-working, amidst leady ores, and the like *additions*; but its copper in a crude, stony form, called *lead-stone*; which last must by repeated roastings be reduced to *copper-stone*, and this again, by smelting, to black copper, before it can be made pure and fine. This crude-stone, with us at Friberg, generally contains between 2, 3, and 4 pounds of copper, and four loths of silver, and is accordingly dosed with *additions*. Now *pyrites* either lodges already in the ore, thus to be treated in its crude state, especially in coarse veins; or is added on purpose, as found necessary; or is entirely wanting, as generally in noble veins: and here it is so much the more needful to be added, as where no *pyrites* is to be had, or proves too expensive to be conveyed to the spot, most of the ore of such places, which is commonly interspersed with metallic spangles, very thinly sown, and, on that account, neither to be washed nor roasted, lies useless and unworked.

That the *pyrites* promotes at least the flux of ores, or rather of their rocky, stony, and earthy admixtures; or briefly, helps to scorify and reduce them to glass, is its known effect in the operation of *crude smelting*. But when such rocky admixtures hold good ores, as of lead, copper, and the like, the use of *pyrites* is superseded, as the above

are

are of themselves sufficiently fusile: and that it is of no manner of service to rocky matters alone, may easily appear, upon dosing barely with *pyrites* such matters, were they without all eyes of ore, and were neither soft flags, nor any leady additions employed therein. And thus *pyrites* aids, or aids not, according as itself is or is not aided. It is in itself stubborn, yet becomes soft and flowing, according as it is treated or dosed: whence it is necessary to consider the refractoriness and easiness of ores in general to flux: and 'tis owing either to the ores themselves, or to their mineral admixtures. In themselves, *glitter*, white and green lead-ores, antimony and yellow *pyrites* or copper-ores are soft-flowing: but white *pyrites* more stubborn, yet smelting in a brisk fire, even when unstripped of its arsenic: more stubborn is the yellowish *pyrites*, which apart difficultly or not at all cakes: most stubborn of all is mock-lead, and next, the earths of *pyrites*, cobald and bismuth, or their *capita mortua* or remainders: yet those of the yellowish more than those of the white; as the former hold more metallic, namely martial, but the latter, more unmetallic earth: Those of cobald and bismuth are highly unmetallic (so far as our experience hitherto goes) and hence not to be fluxed without salts, as we learn from the *smalt-glass*: and as ores hold these three metals, lead, copper, and iron, they in proportion prove either hard or soft flowing, as these metals themselves prove: for it is known, that unmetallic earths flow most difficultly; iron, with difficulty; copper, with more ease, and lead, with most. In regard to their mineral admixture, all ores are properly stubborn; though quartz, compared with any other, scorifies *per se* with the most ease; but with *additions*, particularly lead,

also

also in some measure arsenic, quartz and spaths, are very fluxile: much more stubborn are *glimmer*, Muscovy-glass, talc, cat-silver, shiver and horn-stone; most of all lime-stone, gypsum, alabaster and chalk. All which particulars I have learned from the proofs. It remains to be enquired why *pyrites*, which is properly of the stubborn ores, is a flux; and in what circumstances. *Pyrites* is three-fold; yellowish, yellow and white; or iron, copper and arsenic *pyrites*. The white or arsenic *pyrites* is quite unfit for the operation of *crude-smelting*, and hence kept from it as much as may be; in regard its arsenic eats away and scorifies the lead, which is already amongst it either in eyes of *glitter*, or lodged in the soft leady slags, or otherwise added thereto, as is well known of both these bodies: or again, when the arsenic has nothing to do with lead, it separates with difficulty, or not at all from its earth (as the *crude-working* is a strong smelting fire, wherein it directly cakes therewith, and rather requires a soft roasting fire for its separation) consequently the earth cannot scorify, as it should, to answer the end of *crude-smelting*. Again, this inconvenience happens, that the arsenic, lodging in the iron of the *pyrites* earth, will not be separated from it in the following lead and copper workings, but is still to be separated in that arsenical, irony mass, called *speise* and *leg*. Further, its earth is so crude, as to become, if not unserviceable for scorification, the principal thing here intended, yet not so easy-flowing; especially as the white *pyrites* is so overdosed therewith: and again, it gives none, or but an arsenical, impure *crude-stone*, or regulus.

But the yellowish and yellow; or, as they are cal-

called at Friberg, the sulphur or iron *pyrites*, and the copper-ores are what deserve particular mention here for the operation of crude-smelting, and most peculiarly, the yellowish, as what so completely answer, as to compensate their want of copper: Though indeed it were better, were the common *pyrites* not only coppery, as it generally is at Friberg, but also were copper ore added; as then we might expect a *yield* of copper, to help to compensate the charges in working; and in some circumstances, indeed, where the work shall prove hot and refractory, cannot be omitted without loss in silver-yield, but in itself, and for promoting the principal end of this method of working; that is (1) For the scorification of the rocky, stony, and earthy matters. (2) For making the *stone* or regulus, and concentrating the silver, it cannot be considered as absolutely necessary; as it promotes not the first; and as to the second, lead is sufficient; which is already in the ore in *glitter-eyes*, as coarse veins are never without them; or leady *additions* may supply that want for noble veins; where not only *glitter*, but also *pyrites* is generally wanting.

What the *pyrites* contributes in the operation of *crude-smelting*, is to flux and scorify the stony and earthy matters, to separate the ore from them, and make it give forth itself in what is called the *stone*, or crude regulus. Now as *pyrites* consists of several parts, as sulphur, arsenic, iron and copper, we must enquire which of these it is, that promotes the above effects. The arsenic is here to be secluded, as corroding lead, tainting silver, and as encumbering, nay proving detrimental to the scorification. Copper is in this case to be consider-

ſidered rather as a *patient*, and ſo far good, than as an *agent* in any degree: conſequently, there remain only ſulphur and iron, which from all circumſtances and experiments we may conclude to be the principal agents in the buſineſs of the ſeparation, precipitation, ſcorification, or by whatever other name the proceſs be denominated. That the ſulphur contributes not a little, we may certainly conclude from deſulphurated *pyrites*, never yielding any *ſtone* or regulus; and ſo being unfit for the principal view of this operation. Its efficacy appears chiefly on the rocky, ſtony, and earthy matters, adhering to the good ore, or wherein rather the good ore lies entangled. The large quantity of crude, unmetallic, unfluxile earth, which is not to be forced by the addition of ſoft flowing ſcoriæ, wants ſomething, which, with the aid of the ſulphur of the ore itſelf, may macerate, ſoften, diſſolve, and bring it to ſcorifaction; an effect depending certainly on the acid ſalt of the ſulphur: but though ſpirit, or oil of vitriol act little or nothing upon ſtony and earthy matters; yet we are not from the effects of bodies in their ſeparated, to conclude to thoſe of their mixed, ſtate: oil of vitriol, or of ſulphur, as diſtilled from vitriol or ſulphur, has a different habitude from what it has, while lodged in the ſulphur, and combined with the inflammable earth, and ſtill as different as it; nay, the ſulphur itſelf ſtands in the *pyrites mixtion*.

As to the ſecond, the iron; its neceſſity of co-operation appears clearly hence, that (1) The ſulphur is, in its ſeparated ſtate, entirely unfitted for the proceſs of ſmelting, and would only burn away too ſoon. (2) That in another, even a combined ſtate;

state; for instance, in antimony, where there is certainly no want of sulphur, it would not once work in due manner on the rocky matters; since the sulphur in the antimony does not by far so easily separate from its semi-metallic earth, or regulus, as in the *pyrites*, from the iron-earth, and thus would fail to exert a due degree of activity; not to mention, that the sulphur should help to scorify in the manner the iron does. Besides, the iron has to do with something more than the unmetallic earth, namely the *ory* matters; which last cannot, or, at least, not so well, be affirmed of sulphur; namely (1) The *pyrites* iron, under the direction of proper *additions*, especially leady slags, also leady ores, helps to make the *stone*, corroded by the sulphur, soft and fluxile, and at the same time becomes itself soft and fluxile therewith, that is, a glass or slag. And this proceeds (1) From the easier *terrification* of the *pyrites* and iron itself: but the terrification, or reduction of metallic bodies to earth, is the high way to their vitrification, and scorification, is a species of vitrification. (2) By this means, the good ore, dispersed and spread abroad, and as it were immured in the rock and earth, is set free and fitted for metallisation. (3) The iron, which before was a captive to, but now is released from the sulphur, strikes the sulphur and arsenic out of the ore; nay swallows them up, so that the metal is thereby freed from these gross impurities, or precipitated, as a regulus out of antimony. All which internal elaborations, marked under these three heads, we are to suppose to happen instantaneously, or with a quickness equal to the violence of the fire. But as no separation and precipitation happen without the *separant* entering into the *separand*; so here all the pyrites-iron goes not into the

the flag or scoriæ; nay mostly, or in an unknown proportion, combines with the *crude-stone*, as being ever found to be irony.

Now from what has been said, we may form a judgment of a *crude-smelting*, wherein sometimes iron-stone, sometimes real or corporal iron itself is employed; of which, among others Lohneiss makes mention. It is true, we cannot with proper grounds speak of such a method, if we are unacquainted with the whole dose of *additions*, and with the ore: as little will I affirm, that in some circumstances it may not hit; yet not be unattended with great difficulties, not easily surmountable. Though thus much I see from my own experience, that iron very readily *regulates* or metallises *glitter*, as proving here the most adapted *separant*. But (1) Our business, especially in the matter of *crude-working*, is not with pure *glitter*. (2) Should the iron supply the place of *pyrites*, nay, have a better effect, the stony matters would remain untouched, as being to be fluxed by the sulphur, which is in the *pyrites*, but not in the iron. And lastly, we should consider how it affects the goodness of the copper and lead. With the iron-stone to procure the principal end of the *crude-working*, which consists not only in separation, but in scorification too, the more art is requisite; in that this last, on the score of its incorporated stubborn crude-earth, and impurity, wants for itself the proper aids and helps. Briefly, it holds quite otherwise with the *pyrites* iron, than it does with smelted iron and iron-stone. In the *pyrites* it is not only adapted in a certain manner by nature, but becomes more so in the course of the operation itself; turning to a spongy, subtle earth, both receptive, and

and operative; a thing not to be expected from iron-stone. And he, who has experienced the different habitudes of bodies in their simple, separated and mixt states, will view artificial iron, and the iron-earth of *pyrites* in different lights.

CHAP.

CHAP. XVI.

Containing, I. The hiſtory of the Heſſian PYRITES, called *Terra martis Haſſiaca*. Communicated by M. Roſinus.

GREAT Almerode, a conſiderable village in Lower Heſſe, three miles from Caſſel, and five hours ride from Munden, lies in a very mountainous, and almoſt the higheſt part of Heſſe, and is encompaſſed on every ſide, partly with very tall foreſts, partly with very high mountains, among which laſt the Weiſſner and Herſs, or more properly Hirſchberg, are the principal. The Weiſſner, which is the higheſt in all that country, riſes near the village of Ludenbach, an hour's ride from Great Almerode, and contains a large inexhauſtible ſtore of ſtone-coals, which are there dug in two different places, and conveyed to Altendorff for boiling ſalt: beſides, on its top, which is quite a plain, a mile in compaſs, many peculiar herbs grow, not readily to be met with elſewhere, alſo good paſture-graſs. The Hirſchberg, which is cloſe by Almerode, abounds much with bituminous foſſile wood, or wood-coals, as they are called, alſo with plenty of good bituminous alum-ore, for which two alum huts are built at its foot. The ruggedneſs of the country, and inclemency of the weather, thence ariſing, prove prejudicial both to the agriculture and horticulture about Almerode, the garden-fruits arriving very late there to their perfection and maturity; as I once remember

ber to have seen there, about Michaelmas, a tree with ripe cherries upon it: tho' whatever the country about Almerode may seem to want in this respect, is sufficiently compensated by other advantages; among which we may chiefly reckon the various sorts of clays found there, and called sometimes *crucible* earth, sometimes *pipe*, and sometimes *pottery earth*, according to the various uses they are put to. The pipe-earth is mostly employed by the tobacco-pipe makers of Almerode, Cassel, and chiefly of Munden. The crucible-earth, worked at Almerode itself, gives, by mixing amongst it a coarse, dry sand, those crucibles and retorts, which, for their standing the fire, are famous all over the world, and with which those of Almerode carry on a considerable traffick, by sending yearly whole ship-ladings of them to Bremen, Holland, England, Dantzick, Riga, and other Parts. From the pottery-earth, besides the common earthen vessels, are made those stone-bottles, which are yearly sent in large quantities to Pyrmont, there to be filled with water, and conveyed thence far and near. Among all the abovementioned sorts of clay or earth, are also found various kinds of *sulphur-pyrites* kidneys: those in the white pipe-earth appear in various angular forms; and, as the clay-diggers affirm, are essayed for silver and found *yieldy*. Upon breaking them, they often appear white like the arsenical *pyritas*, and as it were, of a silvery cast; are remarkably ponderous, and either do not at all, or at least it is in a very long time, and, with the greatest difficulty, they crumble in the air; as I have had some exposed for seven or eight years, and in all that time, only some small vitriolic efflorescences observed on the upper sur-

face.

face. In this pipe-earth, which is dug very deep, are sometimes found fossile galls over the *pyrites*, or at least foreign fruits entirely resembling galls. In the greyish crucible-earth are also found *sulphur-pyrites*, though seldom, and in small bits and grains only, but which the crucible-makers carefully pick out from among the clay, because if left behind, they would render the vessel, made from the clay, perforable in a strong heat, and unserviceable: of this *pyrites* the workmen affirm it resolves in the air to vitriol: tho' very slowly, the dark grey potter's clay is properly that earth, which holds the famous *minera martis solaris*, thus magnificently styled by Glauber. The place, where these *pyrites* are found, is at the foot of a hill, not far from the village; where, together with the said potter's clay, in which they lie strewed up and down with some other *coagula* or *drusæ* of Muscovy-glass, they are dug out at a small depth, almost at the day, and found in such plenty, that I myself, and two other persons, had in about one hour and half, with ease, gathered a centner of them: their figure generally, as that of the like *coagula*, is more or less round, also oval; externally they are of a blackish cast, but internally of yellowish, most frequently of a paler, but sometimes also of a darker hue than other *pyrites*; and in gravity and hardness differ nothing from the other *pyrites* abovementioned. Only in this they seem to have something peculiar, that they not only entirely, but also (which chiefly deserves to be considered) very soon resolve spontaneously in a moist, open air, and crumble to a greyish powder, which after elixation and evaporation, yields forth a green iron-vitriol, and an acid liquor. 'Tis true, I am acquainted with *pyrites* enough, which in time change to a vitriolic salt; as such are found in

great variety near Almerode, also in the clay and blue marl pits of Munden, and other adjacent places; yet I know of none undergoing so speedy a change as those Almerode *pyrites* found in the potter's clay: since I have been assured by persons of credit there, that being dug fresh in summer weather, and moistened a little by means of a warm rain, and afterwards lodged in a shady place in the open air, they vitriolise in a few days. Last summer I observed a phænomenon entirely uncommon, and perhaps peculiar to the *minera martis sulphurea*, rather than *solaris*, of Almerode: namely, that having placed a large wooden trough with this mineral, most of it being already become a vitriolic powder, on a floor four story high, which was indeed dry, but sufficiently exposed to the air, fanning though the open windows. In the beginning of the summer, I unexpectedly observed this matter to become moist, and gradually still softer, nay lastly, fluid, and begin to trickle through a small rent in the trough. Upon which this fluid matter, together with its thick bottom, was put into other vessels, and by the addition of more water fully elixated. The clear lie being poured off, was put into open, flat glasses, and committed to the gradually increasing summer heat, till become quite dry: by this means I in some time procured from this liquor a green vitriol, and a yellowish dry bottom or settlings, easily pulverable. But in the immediately succeeding autumn this dry bottom was deliquated anew, and changed to a fluid matter, not unlike, in colour and taste, an unrectified oil of vitriol, in which state it continues to this day. There moreover appears in the course of the crumbling of this *pyrites*, a circumstance altogether peculiar and very memorable; namely, that it then

then (most of all, that which resolves the soonest) heaves or ferments, as it were, from within outwards, comes to have cracks, and thus gradually falls asunder, and acquires a vitriolic salineness. Whence it clearly appears, such fermentative, intestine, dissolutory motion must needs originally arise in the very center of the *pyrites*. In the *conchites bivalvæ* of Landwerhhage, which are still covered with their close natural shells, but internally filled with *pyrites*. I observed in what manner, some, before ever any thing vitriolic could be observed in them, snap asunder in the middle, and open quite wide, in such a manner, as that the hinges, wherewith the shells still remained joined together, stand directly opposite to each other, which can be ascribed to nothing but the above-mentioned cause. Further, some authors have remarked, the *sulphur pyrites*, both in the groove and elsewhere, when lying moist and heaped high on each other, usually to heat from within outwards. And in order to try, whether the same would not hold of the *pyrites* of Almerode, I took between 50 and 60 pounds thereof fresh dug, and stamping them to the finest powder, I moistened this powder gently, and shot it into tall glasses, prepared expresly for the purpose; and tho' left standing open for some time in the free air; yet it did not discover the least degree of heat or warmth: nay, the *pyrites*, thus moist and laid high on each other, would not even bewray the least change, or yield the least vitriol: whether the time of year, as it happened to be October, was unfit for this experiment, I shall not pretend to determine. This very experiment I repeated in another manner, putting small powdered *pyrites*, moistened with brandy, into a low cucurbit, to which I fitted a large helm and receiver, in no case

to

to lose the brandy passing over; which even then, without raising any degree of warmth in the *pyrites*, began mostly in the night time to re-distil over, though slowly, there being, for weeks together, not above half a pint procured: this brandy tasted something of the *pyrites*, and was very phlegmatic; whence I conjecture, not only the bare nocturnal cold, but also the intestine heat of the *pyrites* to have contributed something to its passing over. Be this as it will, thus much at least we may learn from the resolution and vitriolisation of the *sulphur-pyrites*, that in it is certainly included something highly prone to intestine motion; and to be sought for either in the common sulphur or the iron; of both which we know the *pyrites* consists. The phænomina arising from artificial and natural productions, combined with sulphur; for instance, phosphorus and the bituminous alum ores, which take fire in the open air, and resolve to alum, should almost persuade one, that the sulphur ought to be considered as the principal cause of the vitriolescence of *pyrites*: and accordingly I understand the matter thus; the inflammable substance combined with the sulphur of the *pyrites*, is itself by the access of the external moist air, not only first excited, and then the whole concrete put into motion by it, but moreover is still more and more freed, and at length quite separated from its union with the acid; consequently, such acid, after a perfect separation, unites with the iron, and forms a vitriol. By way of conclusion, I add that no one, so far as I know, has hitherto written of the *vitriol pyrites* of Almerode; nor are there any vitriol-huts there. 'Tis true, the alum-boilers prepare from their lie, precipitated by means of urine, a green vitriol,

but

but so poor as to be sold very cheap, it being but little valued. Thus far M. Rosinus.

II. The specific gravity of the Pyrites.

As I myself was without a good hydrostatical balance, I in this case applied to the celebrated Dr. Meuder, who readily gave me his assistance here, and not only examined the *pyrites* and its concomitant matters in the most accurate manner possible, and with repeated care and diligence, but also many others, and those the principal, both dense and fluid bodies, as laid down in the following tables; to which he has subjoined a set of uncommon remarks and principles, and peculiar ways of managing the hydrostatical ballance. The small table of *pyrites*, sulphur, arsenic, &c. might have seemed sufficient for my purpose; but as this is a subject hitherto not so fully and fundamentally examined, the reader will not be displeased if I give the tables at length; the specific gravity of the *pyrites*, and its concomitant matters deserving the utmost regard, and a subject being ever best illustrated by comparison with other matters. Dr. Meuder goes on thus.

As the specific gravity of each body is deemed to be one of its characteristic marks, and as such observations may be supposed of further physical use, we have given the following tables of the specific gravity of the principal and most known mineral bodies.

1 Transparent amber.
2 Colophony.
30 Brown pitch.
43 Black pitch.
111 Asphalum.

 244 Pu-

244 Pumice-ſtone, full of water.
274 Stone-coals.
296 Gum-arabic.
418 Aphronitrum.
430 Hard gypſum, full of water.
438 Red tartar, full of water.
533 Crude ſulphur.
545 Purified ſulphur.
546 Foſſile opal.
556 Sulphur, once melted over.
556 Foſſile ſulphur.
559 Stone-marrow, or lac lunæ, full of water.
559 Crabs-eyes, full of water.
568 Brown glimmer.
601 White Indian porcelane.
611 Facitious black-lead.
616 Sweet vitriol-earth, out of the Minera martis Haſſiaca.
618 Cat-ſilver.
624 Lapis ſpecularis.
630 Bricks, full of water.
630 White miſnian porcelane.
635 Red Japan porcelane, full of water.
639 Cryſtal-glaſs, of burnt flint and ſaltpetre, equal parts.
642 Stone from the Prudel, at the Carlſbad.
648 Chalk, full of water.
658 White Bohemian glaſs.
661 Variegated glitter-glaſs.
668 Red coral.
669 Common blue glaſs.
674 Red bole, full of water.
676 Green glaſs, with one eight verdegreaſe.
677 Amianthus from the Serpentine quarry near Zoblitz.
678 Alabaſter.
679 Dreſden cryſtal-glaſs.

680 Oblong

680 Oblong belemnites, full of water.
680 Horn-ſtone.
681 Ophites, or ſerpent-ſtone.
681 Coral-ſtone.
684 Lapis Lyncis.
685 Stone from the vineyard, from Malaga.
685 Cornu Ammonis.
687 Hungarian marbled diamonds.
689 Druſiform mountain-cryſtal.
690 Ruby-glaſs.
691 Chalcedon, near Zwickau.
692 White marble.
693 Martialiſed oak-wood.
695 Agat.
695 Quartz.
696 Elbe flint-ſtone.
697 Cologne chalk.
698 Red jaſper.
699 Pietra di Venturino.
699 Mother of pearl.
705 Shiver-ſtone.
705 Sulphur flags.
707 Black ſoft grind-ſtone.
709 Red marble.
709 Blue iron-flags.
713 Lime-ſtone.
716 Ætites.
718 Quartz, near Rudelſtadt, in which there is native gold.
722 Soft ruddle, full of water.
726 Violet-ſtone.
727 Alumen plumoſum.
738 Granate-ore, near Pirna.
759 Razor-hone, ſoft and white.
771 Red arſenic, or ſandarach.
781 Foſſile verdegreaſe, or chryſocolla.
784 Highly red ſandarach.

785 Dingy

785 Dingy sandarach.
796 Cadmia fornacum, for brass.
807 Orpiment.
813 Iron-scales.
821 Smelted luna cornua.
827 Fossile black-lead.
828 Lapis de tribus.
833 Yellow arsenic.
834 Magnet, full of water.
837 Small granates.
838 White arsenic.
841 Pyrites from the Croner.
843 Yellow pyrites, from Lorentz.
844 Ordinary, or poor cadmia fornacum.
848 Blend, or mock-lead.
849 Copper-ore, from Temeswaer.
854 Ceruss, full of water.
858 Hungarian copper-ore.
858 Common antimony.
861 Copper-ore, near Rudelstadt.
863 Yellow pyrites, from Neustadt.
863 Large granates.
863 Ore of antimony.
864 Close black iron-stone, from Kuhnheyde.
865 Yellowish pyrites, from the Hartz.
870 Blendy, or mock-leady cadmia fornacum.
871 Tinny black-lead.
873 Pyrites-balls, from the Andreasberg.
883 White spath, from the Seegen-Gottes.
884 Toplitz pyrites.
891 Pyrites from the Geyer.
892 Pyrites from Temeswaer, full of water.
895 Snail-cobald from Schneeberg.
897 Bohemian granate-ore.
900 Blood-stone, or glass-head.
905 Pretzschendorff pyrites.
906 Factitious fly-stone, full of water.

907 Yel-

907 Yellowish pyrites, from Johan-Georgenstadt.
907 Yellowish pyrites, from the Halsebrucke.
908 Yellow pyrites, from Sweden.
912 Minera martis Hassiaca.
914 Yellowish pyrites, from Sweden.
915 Glass of antimony, made *per se.*
916 Yellowish pyrites, from the Ehrne-schlange.
917 Yellowish pyrites, from the Zug.
919 Close, or firm pyrites from Temeswaer.
924 Hungarian quicksilver ore, full of water.
940 White pyrites, from the Himmels farth, and Gunther.
945 Glass of lead.
955 Cinnabar, fixed with silver-filings.
956 Testaceous-cobald, or fossile fly-stone.
959 Smalt-cobald, from the Seegen-gottes.
962 White pyrites, from the Kuhschacht.
966 Transparent red-goldish ore.
968 Smalt-cobald, from Schneeberg.
975 Glassy ore.
976 Bismuth-ore, dove-necked.
978 Regulus antimonii stellatus.
980 Repeatedly purified regulus of antimony, with twice the quantity of iron.
989 Tin-stone.
990 Clear lead-glitter, or galena.
991 Cobald, near Rudelstadt.
993 Zink.
993 Regulus of antimony, with twice the quantity of copper.
993 Snail-cobald.
997 Coarse lead-glitter.
997 Fine tin.
999 Coarse mineral cinnabar.
1001 Common, or alloyed tin.
1002 Kupffer nickel.

1003 Mi-

1003 Mineral cinnabar in grains.
1003 Speise from lead-work.
1004 Drusiform lead-glitter.
1005 Diced lead-glitter.
1006 Factitious cinnabar.
1007 Iron.
1009 Silver-litharge.
1013 Speise, of four parts zink, and one part copper.
1022 Brass.
1022 Malleable prince's metal, of copper and cadmia fornacum.
1026 Silver alloyed six parts.
1028 Copper.
1029 Bismuth.
1046 Silver.
1058 Villach lead.
1073 Quicksilver.
1098 Gold.

Remarks on the HYDROSTATICAL BALANCE, and its use.

I. For a balance to be sensible and accurate, that is, constantly to shew, in an uniform manner, the same degrees, the stem must be hollow and open a-top, for the air in the body below to have a constant free communication with the external air.

II. Consequently, such are unfit whose stems are either not hollow, or yet are close a-top; as the common glass and amber-sort.

III. The longer the stem, the better; as then the greater number of degrees may be marked thereon, and the more different bodies it can bear, without sinking down.

IV. The

IV. The stem must also be of equal thickness and strength throughout, otherwise it sinks not down straight, proportionally to the weights applied.

V. The best figure for the lowermost body of the balance is the conical, as such, may with less resistance force through the fluid.

VI. The lines, or degrees on the stem, must be made accurate and equal to each other, and one tenth of an inch is a proper measure, or standard to divide by.

VII. To the cone, or belly below, there is a perforated scale of a balance appended, for the fluid to pass through, and thus the true degree of gravity not to suffer any alteration. These small perforations, however, have not hindered the weighing of running mercury, without the least of it straining through.

VIII. The very balance wherewith the above remarks were made, has a stem of nine inches, each divided into ten parts, making in all ninety divisions; with one grain of fine silver, it sinks six lines, consequently bears in all (from one to a ninetieth degree) only fifteen grains; whereas my amber stem, eight inches long, and containing eighty lines, scarce sinks one line with one grain of silver; and thus the first is six times more sensible than the second. A grain I call the sixty fourth part of a drachm, namely, the piece which is marked with sixteen standard penny weight.

IX. A

IX. A difficulty still attending a balance so sensible is, (as then it must be sensible for the observations) that very few bodies can be weighed by it; for the most either quite sink the balance under water, or leave it quite a-float a-top, so as not to sink at all; as, among all the above bodies, scarce ten have, barely of themselves, shewn their degree of gravity. But this difficulty may be easily obviated, by correcting the levity and gravity, by the adding and taking away of weights, and then calculating how many degrees such weights make out, and how much must be added or deducted.

X. The fluid wherein you weigh must be constantly one and the same, also be of the same degree of warmth, or of cold; whence, in winter, the degrees appear not the same as in summer, even through the very same water be used.

XI. The degrees on the above balance must be counted from below upwards, as these must encrease with the encrease of gravity.

XII. All the bodies you would weigh are previously, by means of a pencil, to be wetted with water; otherwise the air-bubbles adhering to the body under the water, make it lighter than it is.

XIII. Also all porous bodies, as crabs-eyes, chalk, &c. must be suffered to absorb their fill of water; else also the body proves lighter than it really is.

XIV. In regard to artificial, and other bodies, care is also to be had, that they contain no included

cluded air, which cannot be diſcharged; as is often the caſe with caſt ſulphur, and alſo the *ætites*.

XV. At laſt, all the bodies muſt be weighed, in the moſt accurate manner, on an aſſay-balance of equal weight, one grain thereof anſwering exactly to ſix lines: all bodies, weighing three drachms, have, for the above obſervations, been weighed with the utmoſt accuracy.

XVI. But for examining the comparative gravity of ſalts, as alum, borax, vitriol, ſal-gem, &c. inſtead of water, rectified ſpirit of wine is to be uſed, as not diſſolving therein in the courſe of the weighing.

XVII. In order to weigh a coſtly body, of which a heavy piece cannot be had, or if too heavy, none of it can be ſtruck off, look in the table for a body approaching tolerably near to it in ſpecific gravity; and of this laſt weigh, on the aſſay-balance, an equal weight againſt the coſtly body; then weigh both in water; laſtly, add to or ſubſtract their difference from the known body in the table, according as the coſtly body happens to be lighter or heavier, and you procure the true ſpecific gravity of the coſtly body, by the proportion in the table.

A curious and uſeful contrivance for ordering a tall cylindrical glaſs in ſuch a manner, that upon pouring into it an unknown ſaline water, the hydroſtatical balance ſhall inſtantaneouſly, without a calculus, ſhew the number of grains or drachms of ſalt in a pound of the ſaline water.

(1.) Cauſe to be made a tall cylindrical glaſs, about twelve inches high, and two and a half thick; (2.) fill

(2.) fill it up with running water; (3.) append to the cone of your balance so much fine tin as shall sink nearly under, yet with its uppermost point appear above the water; (4.) mark the place on the glass, where the upper edge of the cone stands: (5) now dissolve in four pounds of such water, one loth, or half an ounce of common salt; (6.) with the salt-water fill the cylindric glass to the preceding height of the common water; (7.) hang your balance therein, as before, and when it comes to rest, mark again, where the upper edge of the cone stands below; (8.) divide the distance between the two points marked, into sixty equal parts (each of which is to shew a grain) and write the numbers from below upwards; (9.) and thus the balance will, with its upper edge, shew the number of grains of salt in a pound of each saline water, upon filling therewith the cylinder: (10.) but if the balance refuse to sink, 'tis a sign there is not above a drachm in one pound of the water: hence mixing one pound of the saline water with one of common, and then, in the manner above, examining this weakened water, and doubling the grains found, you again procure the true *yield* of salt.

The gravity of different fluids compared.

300 Rectified spirit of wine.
332 Pontack.
333 The Weiseritz-water.
333 The Wolckenstein bath-water.
333 Rhenish wine.
334 The Radeberg bath-water.
334 New Misnian wine.
335 The Fress-water, near Graupen.
336 The cold Caroline Prudel-water.
357 The cold Caroline Muhl-bath-water.

339 The

339 The Zedlusch bitter water.
341 The sound urine of sanguine constitutions.
343 Cow's milk.
343 Dresden beer-wort.
344 Dresden double beer.
348 Asses milk.
361 Red Misnian must.
374 Common spirit of salt.
378 Common small *aqua fortis.*
391 Common good *aqua fortis.*
516 Oil of tartar, *per deliquium.*
606 Common oil of vitriol.
4500 Quicksilver.

But as at present our principal view is to the *pyrites,* we shall bring it, in its kinds and appendages, with a reduction of the numbers, into the following table apart.

1 Crude sulphur.
12 Purified, or common sulphur.
23 Fossile sulphur.
23 Once-melted sulphur.
172 Sulphur-flags.
251 Red arsenic, or sandarach.
274 Orpiment.
295 Lapis de tribus.
300 Yellow arsenic.
305 White arsenic.
330 Yellow pyrites.
375 Yellowish pyrites.
423 Fossile fly-stone, or testaceous cobald.
429 White pyrites.
435 Smalt-cobald.

Thus far Dr. Meuder.

We then see how *pyrites,* and its sulphur and arsenic, compared together, and with other bo-

dies, ſtand related in ſpecific gravity; and by this means not only learn to diſcover the nature of the reſpective bodies: for inſtance, that arſenic approaches extremely near to the nature of metals. We are alſo hereby furniſhed with a teſt to judge of the relation between this and other bodies in the firſt table, which may be ſafely depended on: for thus, a ſulphur, the more arſenical it is, the heavier; an arſenic, the more ſulphureous, lighter than a white cryſtalline arſenic; and an orpiment muſt contain more of arſenic than of ſulphur; a *pyrites*, and an *arſenic pyrites*, the heavier, the more arſenical, *&c.* Only it is well to be obſerved, (1.) that the body to be examined have not the leaſt foreign admixture, as ſtone, earth, or other ore adhering; (2.) be not fibrous and porous, but cloſe or denſe, for the air not to lodge entangled in it, or, notwithſtanding, being capable of being exhauſted, as both theſe circumſtances render the proof fallacious. This, for inſtance, is the reaſon why crude ſulphur appears lighter than purified ſulphur; whereas crude ſulphur, when of a grey caſt, as this was, and generally is, holds a little arſenic, and though never ſo little, it muſt at leaſt preponderate purified ſulphur. Further, foſſile ſulphur weighs more than purified ſulphur, the latter not being ſo cloſe or denſe as the former; whence that ſort melted once more over, and thereby becoming cloſer, is heavier than the purified. Yet cloſeneſs, or denſity and gravity go not always hand in hand; flint, for inſtanee, is lighter than quartz, and this much lighter than ſpath: white cryſtalline arſenic is much lighter than foſſile fly-ſtone, which ſublimes entirely in form of a white arſenie, whence the cryſtalline arſenic muſt either have acquired or loſt ſomething, which muſt needs have made it lighter. Nor need we wonder that yellow, or copper *pyrites*, is

is lighter than yellowish, or iron *pyrites*, though the latter consists only of iron and sulphur, but the former of copper and arsenic (at least more than the latter) which are heavier than iron and sulphur; and from this we must needs conclude *copper-pyrites* to hold more unmetallic, consequently more light earth. But, to say the truth, the hydrostatical balance is far from being that absolute means of attaining to the entire and full knowledge of bodies, which some philosophers, who might be too nice to smut their hands with chemical processes, would have us to take it for, whatever short auxiliary means it may otherwise be: nay, nor this balance, nor the fire alone, nor air, nor depart-waters alone, nay, often, not all of them together are sufficient to disclose to us the secrets of nature.

III. *Miscellaneous Observations and Experiments on the* PYRITES.

I. Native silver is most commonly found either in pure quartz, or near and on cobald, and consequently on an arsenic-ore; though *misspickel*, or *arsenic-pyrites*, equally with cobald, be arsenical, yet we have hitherto had no instance of native silver thereon, which must be owing to its iron, or other earth, hindering the production thereof.

II. Native gold is, in like manner, commonly found in pure quartz, never on cobald; whereas, on the contrary, 'tis to be found on *misspickel*.

III. On yellowish and yellow *pyrites* we find ner gold nor silver, at least, not as growing from such *pyrites*.

IV. I have been lately shewn a sample of *kneiss* with yellowish *pyrites*, and capillary silver lying thereon, as if the silver grew from the *pyrites*; but

first, it follows not hence, that because it lay on, it therefore proceeded from it: again, though we should allow this, yet it must needs be ascribed to the arsenic, this *pyrites* being hemispherical, and thus arsenical, like what we call *cobald*, at the Halsebrucke.

V. Nay, this sample would seem to shew, that the native silver comes to be *weathered* or destroyed again. 'Tis true, this I cannot conclude from the sooty appearance, which, though in itself of some consequence, yet is not to be depended on, as this or the like sample would require an observation of many years; as, whether in that time the silver may be destroyed again, and in what manner; at least, 'tis a thing not readily credited by every one; and the crumbling and falling to pieces of the sample, is well to be distinguished from its *weathering*.

VI. Should native silver happen to be *weathered* again, it must needs be arsenical; in the manner it is affirmed, that native gold is often mercurial, and thus pale.

VII. It is true, *pyrites* is the mother of vitriol, but neither the mother, nor a recrement of metals, as was formerly thought *, but an ore *per se*.

VIII. As to what is said of the existence of gold in an Hungarian vitriol, communicating itself to the depart-water prepared therewith, it proves a self-deception, arising either from the experiment, or the judgement formed upon it: for, though the mint-master in Becher had found gold in it, it would neither be a fixation, nor an extraction, but a production, rather of a thing existing in neither of the matters employed, but produced from both †.

IX. Cane-

* Canepar. Desc. I. c. 2. Ludov. de Comit. de Met.

† Tollii Epist. Itiner. V. p. 175. Becher. Phys. L. 1. Sect. 3. c. 3. p. 142.

IX. Caneparius § pretends to have seen with his own eyes, rubbed marcasite, or *pyrites* changed, by pouring on vinegar, to quicksilver; which well agrees with what I adduced above from Boyle, at the close of chap. XIII.

X. Pomet was assured, a certain abbot had, from a certain marcasitical vitriol-yielding *pyrites*, to be found in the clay-earth near Passi, a mile from Paris, prepared his *universale*.

XI. That *pyrites* is of a mercurial nature, Albertus affirms may be concluded from its giving to copper a white colour ‖.

XII. Mathesius mentions a marcasite holding quicksilver and an arsenic ore (cadmia) from which, upon striking, there squirted out quicksilver §§.

XIII. How to draw quicksilver from vitriol, see Caneparius. ††.

XIV. Calx of lead digested with sal ammoniac, salt of tartar, and stale urine, and at length distilled, yields an arsenical odour, nay, at last, a beautiful phosphorus.

XV. I have had from Neu sol, in Hungary, a white salt, under the appellation of a white vitriol, there called *strep*, of an oblong, tender, crystalline form.

XVI. The Radberg-bath comes from a *pyrites* extremely pure, above all other groove-*pyrites*, in iron vitriol.

XVII. In Sweden, in the large copper-groove at Fahlun, there was found, as Leyel ** relates, a man's body, which had lain there for forty years at least,

§ De Atrament. Descr. I. c. 10. p. 63. It. c. 18. p. 108.
‖ Ludov. de Comitibus de metallis, p. 236.
§§ Libavius de natura metall. Lib. I. c. 1. p. 7.
†† P. 218.
** Acta Lit. Suec. Trimestr. prim. an. 1722. p. 250.

least; not only fleshy, uncorrupted, and sweet, but also sheathed, and done all over with vitriol, in manner as if candied.

XVIII. But to see how corrosive things, as vitriol, which destroy not, nay, rather preserve dead bodies, are more active and operative on living ones, we need only recollect what is practiced by the Easterns, who shave themselves with a mixture, consisting of crude earth and orpiment; yet, if care be not had, come to have their flesh perforated, or their skin become like Cordouan leather *,*.

XIX. To try the effects of vitriol on vegetables, I dissolved vitriol in water, wherein I soaked ten grains of barly for twenty four hours, then letting them dry, they became quite black. Of these no more than two came up, with very weakly stalks, and small ears. Whether this was owing to the vitriol, or the great degree of drought, having planted them a little too late, I know not; yet vitriol appears to have but little fruitfulness in it, especially from the vitriol-earth at Rogau in Silesia, which being at first employed as a manure, rendered the fields barren *.

XX. Dr. Gould, of Oxford, has observed, that oil of vitriol does, by means of the air, encrease in weight, having, for that purpose, exposed a highly dephlegmated oil in an open wide glass, and weighed it accurately every day. In the space of fifty seven days, three drachms of oil of vitriol came to nine drachms, thirty grains. The first day the oil increased one drachm and eight grains, afterwards, from day to day, still less, nay, the last day, scarce half a grain. This succeeds in moist foggy weather better than in dry, also in a wide than narrow vessel †. XXI. To

, Tavernier's voyages, p. 166.

* Bresl. natur-und. medicin-geschichte im jahr, 1718. Jul. p. 1402.

† Phil. Trans. No 156. p. 496.

XXI. To shew the volatilisation of metals, Mr. Boyle alledges the following experiment: if you distil thin copper-plates with an equal, or twice the quantity of mercury sublimate, there remains something below, running, and inflammable, like Spanish or sealing-wax, which being powdered and exposed to the air, then saturated with spirit of salt; yields something like a verdigrease; and this, again, distilled with tripoly, or the like, gives a clear liquor, like spring-water, which turns green with sal ammoniac, or a volatile salt §.

XXII. Swedenberg has, in a *prodromus*, attempted to discover, in a geometrical way, and by the hydrostatical balance, the nature of bodies; but such conclusions, however, appear to me to be premature, it being necessary, first of all, not only to repeat and verify several, but, much more so, to make new experiments.

XXIII. In the Salberg-groove, in 1696, some running quicksilver was found, but never at any other time; also once, some in Lapland §§.

XXIV. As I was concluding this impression, I had some *pyrites* sent me from Alonitz, in Russia, of which I shall only say, that it differs not from other *pyrites*. The copper-ore in the Schinifelgi-groove, which is lasulous, holds forty five pounds of black copper. At the groove Bogatvi Mednoi Jamii, also at the Ninifelgi Knordu, there *breaks* a fine quartz with native copper: and which is very remarkable, in the district of Nerzinskoy, in the groove Bajatky, there is found a fine-grained glitter, or galena, containing eighty five pounds of and four loths of silver.

XXV. Take one pound of *marcasita aurea*, says Mazotta **, and dissolve it in two pounds of depart-

§ Boyle on the wholesomeness of the air.

§§ Leopoldi relatio de itinere suecico, p. 81.

** De triplici philosophia, p. 202.

part-water, to which put four loths of sal ammoniac, pour off the solution, suffer it to evaporate, and the *marcasita* remains at bottom. Take of this marcasite twelve loths, gold-calx, or leaf-gold, two loths; sal ammoniac, and mercury sublimate, of each two loths; pure running quick-silver, sixteen loths; mix all together, and sublime for seven times, or so often, till at length all come to remain fixed at the bottom, and each time the sublimate is again to be mixed with what remains ta bottom: mix this with two loths of sal-ammoniac, and imbibe it with one pound and a half of the alcali, to be described below, and the whole will turn to an oil. Give a gentle fire in the furnace called Piger-Henricus, with coals, or with the lamp, for a month, and it will become dry *(congelabitur.)* Of this medicine take two loths to ten pounds of well purified quicksilver, give a gradual fire in a wind-furnace, and let it stand for an hour in flux, and it will be fixed to a gold, and tinge copper and silver. The alcali for the purpose is thus prepared. Pour vinegar on alcali, 'till it come to clot, or bear being made into balls, and let it dry in the sun, then give a reverberating fire for twenty four hours; rub it fine, and dissolve it in twice its quantity of distilled vinegar; distil, cohobate with the very same vinegar; distill once more, and let it run, *per deliquium*, in a moist place, on a marble or glass; dry it again, and again run it, the process is to be frequently repeated; and, what is surprising! it reduces all spirits and bodies *(spiritus et corpora)* to a water, and is a highly valuable secret.—Let who will try it for me, I cannot.

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CORRIGENDA.

PAGE 56. *line last*, read *been*.
p. 80, *l.* 19, read *receptive.*
p. 136, *l.* 8, read *contact.*
p. 140, *l.* 4, read *heavy.*
p. 156, *l.* 7, read *act.*
p. 178, *l.* 11, read *confections*
p. 202, *l.* 12, read *it.*
p. 218, *l.* 6, read *illustration.*
ib, *l.* 7. read *demonstration.*
p. 220 *l.* 2. for *rites*, read *pyrites.*
p. 231, *l.* 9, read *effect.*
p. 234, *l.* 26, read *edulcorate.*
p. 276, *l.* 19, read *preferred.*
p. 349, *l.* 28, read *a different, as it.*

FINIS.